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SECTION 1. INTRODUCTION

The Metropolitan Highway System (MHS) is a collection of assets which include highways, roadways, tunnels, bridges and related support facilities that are owned and operated by the Massachusetts Department of Transportation (MassDOT). These assets are located in the greater Boston metropolitan area. MassDOT is responsible for the safe and efficient operation of the MHS, one of the most important elements of the Massachusetts transportation network. The MHS serves hundreds of thousands of motorists every day, including commuters traveling to work, truckers moving goods into and out of the state, and visitors who come to enjoy the state's many cultural, recreational, and historic attractions.

In accordance with the provisions of the Trust Agreement under which the MHS is financed and operated, MassDOT is required to have the MHS assets inspected by an independent consultant at least once every three fiscal years and submit a report setting forth: (i) the independent consultant's findings as to whether the MHS has been maintained in safe and good repair, working order and condition, and (ii) its recommendations as to the proper maintenance, repair and operation of the MHS during the ensuing three fiscal years and an estimate of costs necessary for such purposes.

TranSystems was retained by MassDOT to act as the independent consultant for the 2015 Triennial Inspection of the MHS assets and was tasked with the following:

- Perform a visual inspection on a representative sample of assets from each asset class that have not been inspected since the previous triennial inspection. Perform an independent verification (QA) of a representative sample size of assets that have been inspected or assessed within the last three years by MassDOT or independent third parties.
- Gather available information in MassDOT's possession relating to inspections, maintenance or repair activities, and new construction of MHS assets performed since the previous triennial inspection. Meet with MassDOT staff to identify and discuss any areas of concern or special interest.
- Record the visual inspection condition information on a customized ESRI Data Collection Application using a tablet to be inclusive of GIS data points (Latitude/Longitude) with digital photographs.
- Create an Asset Inspection Manager (database) for storage and processing of the condition information collected with the Data Collection Application. Import data from previous Triennial Inspection Access databases into an Asset Inspection Manager to supplement new inspection data.
- Prepare estimated costs necessary to update and/or maintain the MHS assets in a State of Good Repair for the next 5, 10 and 20 years.
- Prepare a summary report detailing the results of inspections and the associated projected costs necessary to maintain the MHS in a State of Good Repair.

SECTION 2. DISCUSSION OF ASSETS

The Metropolitan Highway System (MHS) is composed of transportation assets that were previously under the jurisdiction of the former Massachusetts Turnpike Authority. The combined MHS transportation network is a key component of both the Interstate Highway System and the regional highway network serving metropolitan Boston. MHS assets include both new and old tunnels, highways, bridges and buildings. These assets have a complex system of supporting infrastructure which includes, but is not limited to: tunnel ventilation systems with heavy machinery and high-voltage electrical systems housed in a number of separate vent buildings and electrical substations; drainage systems, including pump stations with mechanical equipment and networks of piping; and a number of building structures that support highway operations, toll operations, maintenance and State Police activities.

The MHS assets are subject to a wide range of operating conditions. These conditions include damp, corrosive environments; vehicle exhaust which coats tunnel surfaces with a layer of carbon residue; severe winter conditions, including exposure to deicing agents, freeze/thaw cycles and snow plowing operations; vibration from heavy traffic loadings and machinery; and unanticipated events such as incidents involving over-height vehicles and vehicle collisions, all of which have impacts on the infrastructure. Constant wear from increasing traffic, harsh New England weather, and the increasing age of the MHS adds to the need to inspect the condition of these assets and undertake required maintenance/corrective action to preserve their function and value.

Table 2-1 provides an overview of the MHS transportation network by geographic area. Generally, the assets within each of these four areas were constructed as separate, distinct projects during various time periods.

Metropolitan Highway System	***Approximate Date Opened***
Sumner/Callahan Tunnels	Sumner 1930's; Callahan 1960's
Boston Extension (Weston to Boston)	1964
Central Artery North Area (CANA) Tunnel	1980's
Central Artery/Tunnel	Ted Williams Tunnel 1996; Central Artery 2003

Table 2-1 – MHS Transportation Networks

2.1 History

Until November 2009, the Massachusetts Turnpike Authority owned and operated many of the MHS facilities as currently defined. The Authority was originally created in 1952 by the Commonwealth of Massachusetts to construct, maintain, repair, enlarge, improve and operate an express toll highway, which became known as the Massachusetts Turnpike (I-90). This initial Massachusetts Turnpike, which extends approximately 124 miles from the Massachusetts – New York border in the Town of West Stockbridge to the greater Boston area, initially opened to traffic in May 1957 and terminated west of Boston at the interchange with Route 128/I-95. The 12 mile extension of the Massachusetts Turnpike from Route 128/I-95 to downtown Boston, known as the Boston Extension, opened to traffic in September 1964. The Boston Extension and the Route 128/I-95 interchange are the only portions of the Turnpike roadway that is now part of the MHS.

In 1958, the Massachusetts Turnpike Authority was authorized by law to construct the Callahan Tunnel, to acquire and make necessary repairs to the existing Sumner Tunnel, and to operate and maintain both

tunnels. These tunnels, crossing beneath Boston Harbor, served as the primary link between downtown Boston and Logan International Airport in East Boston. In the early 1990's, the Commonwealth of Massachusetts began construction of the Ted Williams Tunnel, providing a third harbor crossing. In July 1995, the Massachusetts State Legislature enacted the Ted Williams Tunnel Act, which authorized and directed the transfer of the Ted Williams Tunnel, including all responsibility for the operation and maintenance thereof, from the Commonwealth to the Massachusetts Turnpike Authority effective December 14, 1995.

In March 1997, the Commonwealth of Massachusetts enacted legislation that established two systems to be owned and operated by the Massachusetts Turnpike Authority: the Western Turnpike and the Metropolitan Highway System. The Western Turnpike is now defined as the express toll highway, designated as Interstate 90 (I-90), which extends from the Town of West Stockbridge to, but not including, the interchange of I-90 and State Route 128/I-95 in the Town of Weston. At that time, the MHS network consisted of the Boston Extension and the three tunnels connecting downtown Boston with Logan Airport and points north.

In 2009, all Massachusetts Turnpike Authority assets were transferred to MassDOT jurisdiction. The Metropolitan Highway System legislation allowed for the addition of highway, tunnel, and bridge components to the Metropolitan Highway System as determined by the General Court and state legislature.

2.2 Overview of MHS Network

The MHS consists of four major transportation networks as previously listed. Figure 2-1 shows the general location of each of these networks. These networks include a number of interchanges, toll plazas and ramps that interconnect the MHS assets with each other, as well as provide connections to other highways and local roadways.

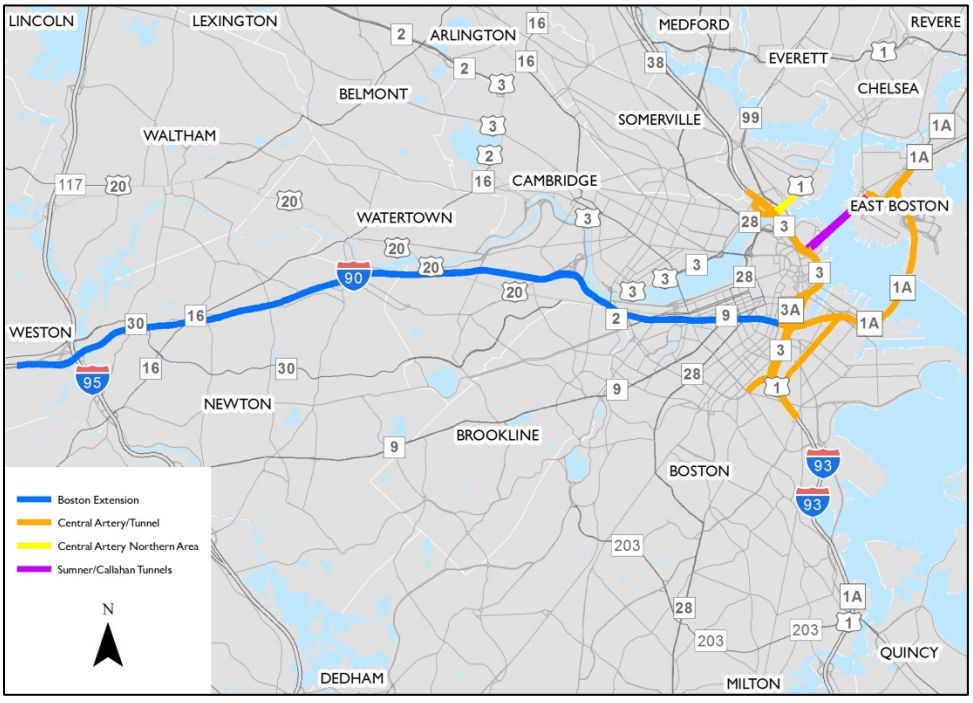

Figure 2-1 – Components of the Metropolitan Highway System

The overall MHS transportation network consists of almost 250 lane miles of roadway of which approximately two-thirds are toll roads and one-third are non-revenue. The network includes:

- 227 bridges and viaducts, including:
  - Leonard P. Zakim Bridge
  - Allston Interchange Viaduct
- Seven major tunnel structures, including:
  - Three tunnels under Boston Harbor (Ted Williams Tunnel, Sumner Tunnel and Callahan Tunnel)
  - I-93 Northbound and Southbound tunnels (Thomas P. "Tip" O'Neill Tunnel) through Downtown Boston
  - I-90 Connector Tunnel under Fort Point Channel and through South Boston
  - Central Artery North Area (CANA) Tunnel beneath City Square through Charlestown
- At-grade highways and roadways, including:
  - Boston Extension: A portion of this highway includes air-rights associated with major developments located above the Boston Extension in the Back Bay area, resulting in what is commonly referred to as the Prudential Tunnel or Prudential Passageway. These air-rights developments include: the Prudential Center complex, Hynes Convention Center, Shaw's Market, Copley Place, and the John Hancock Garage.
  - Frontage Road
  - South Boston Bypass Road
  - Massport Haul Road

According to the Traffic and Revenue Study prepared for MassDOT dated January 28, 2010, the following are the approximate average daily traffic volumes on selected segments of the MHS.

Roadway	Type	Average Daily Traffic (ADT) (vehicles per day)
Central Artery I-93	Non-revenue	140,000 – 180,000
Ted Williams Tunnel	Toll (inbound)	70,000
Sumner/Callahan Tunnels	Toll (inbound)	48,000
Boston Extension	Toll	103,000 – 128,000

Table 2-2 – MHS Average Daily Traffic Volumes

This infrastructure includes thirteen major tunnel ventilation buildings and seven fan rooms that provide ventilation to the tunnels, as follows:

Metropolitan Highway System	***Ventilation Facilities***
Central Artery/Tunnel	7 Vent Buildings and 3 Fan Chambers
Sumner/Callahan Tunnels	4 Vent Buildings
Central Artery North Area (CANA) Tunnel	2 Vent Buildings
Boston Extension (Weston to Boston)	4 Fan Rooms (Prudential Passageway)

One of the buildings housing a ventilation system (Vent Building No. 3) is incorporated as part of a waterfront hotel, and another ventilation system (Vent Building No. 4) is incorporated into a MassDOT owned office building/parking garage structure (Parcel 7). Both of these are major ventilation structures adjacent to the Surface Artery and not generally visible to the public.

The MHS support infrastructure also includes stormwater pumping facilities, as follows:

Metropolitan Highway System	***Stormwater Pumping Facilities***
Central Artery/Tunnel	29 Pumping Stations
Sumner/Callahan Tunnels	6 Pumping Stations
Central Artery North Area (CANA) Tunnel	1 Pumping Station
Boston Extension	4 Pumping Stations

In addition, there are approximately 90 Utility Rooms and three Electrical Substations within the Central Artery/Tunnel (CA/T) portion of the MHS. Other MHS supporting infrastructure includes three Communication Tower/Facilities on the Boston Extension.

The MHS also includes the following operations/support facilities and buildings in addition to the Vent Buildings and facilities summarized previously:

- District 6 Headquarters at 185 Kneeland St. Boston
- Highway Operations Center (HOC) in South Boston
- Toll Plazas and Toll Administration Buildings
- Maintenance Garage/Facility (M-8) in South Boston
- Parcel 7 Building & Garage at 136 Blackstone Street in Boston
- Sumner/Callahan Tunnel Administration Buildings: one in the North End and two in East Boston
- Emergency Response Stations
- State Police Troop E Barracks in South Boston (includes Emergency Response Station No. 2)

2.3 MHS Facilities

Each of the four transportation networks that comprise the MHS is described on the following pages:

Central Artery/Tunnel

The Central Artery/Tunnel is a complex system of roadways, bridges, tunnels and structures which carry portions of I-90, I-93 and US-1. It connects I-93 with I-90 and US-1 and connects to the Sumner/Callahan Tunnels. Twenty-five associated ramps connect the I-93 and I-90 Tunnels to surface arteries and interchanges.

The Ted Williams Tunnel connects the Innovation District to Logan Airport and East Boston via a tunnel under Boston Harbor. With construction of the I-90 Connector portion of the Central Artery/Tunnel system I-90 was extended to South Boston and Logan Airport in East Boston.

The Central Artery/Tunnel network consists of the following eight areas as shown on Figure 2-2:

- South Bay – I-90/I-93 Interchange
- I-90 Connector Tunnel - I-90 between the Boston Extension and the Ted Williams Tunnel
- South Boston – Seaport Access

- Ted Williams Tunnel – I-90 beneath Boston Harbor between South Boston and Logan Airport
- East Boston – I-90 east of the Ted Williams Tunnel
- Massachusetts Avenue – I-93 Interchange with Massachusetts Avenue
- Downtown – I-93 Tunnels from South Bay to North of Causeway Street
- North of Causeway Street – I-93/US-1 Interchange to Cambridge Street

This network includes approximately 107 lane miles of roadway, primarily tunnels and bridges, of which approximately 35 lane miles are toll roads. The tunnels include seven ventilation buildings, three fan chambers, 29 pumping stations and approximately 90 utility rooms.

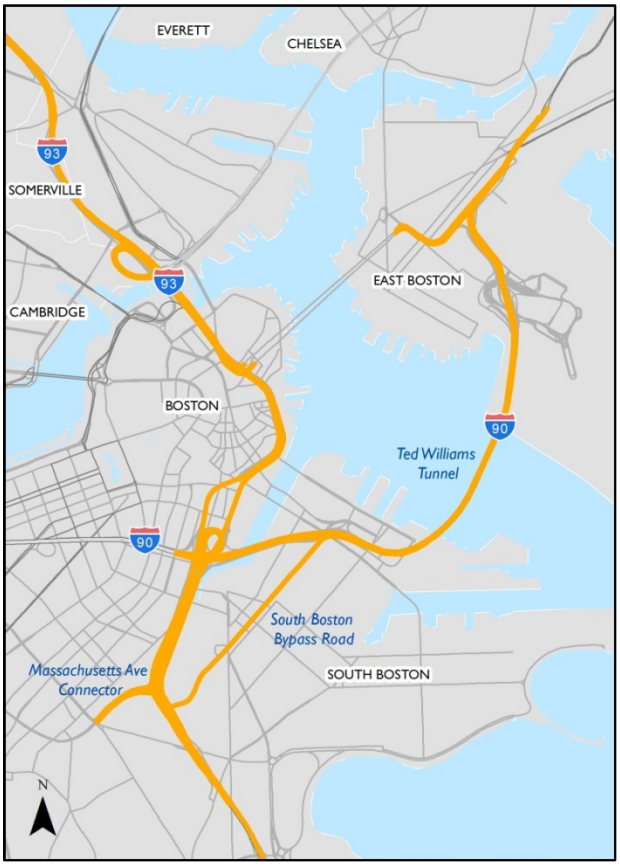

Figure 2-2 – Central Artery/Tunnel System

Sumner/Callahan Tunnel

The Sumner/Callahan Tunnels, which carry State Route 1A, connect I-93 and downtown Boston to East Boston and Logan Airport. The Sumner Tunnel was constructed in the 1930's and initially served as a two-way roadway. The Sumner Tunnel was rehabilitated in the 1960's when the Callahan Tunnel, an independent parallel tunnel structure, was constructed. When the Callahan Tunnel was completed, it was dedicated to outbound (northbound) traffic and the Sumner Tunnel dedicated to inbound (southbound) traffic. Until 1995, when the Ted Williams Tunnel was completed, these tunnels served as the primary link between Downtown Boston and Logan Airport. The Sumner Tunnel, which carries traffic into downtown Boston, is a toll facility.

The southerly ends of both tunnels connect to ramps that were constructed as part of the Central Artery/Tunnel Project. The Sumner/Callahan Tunnels are 5,600 feet and 5,900 feet long respectively. This transportation facility includes four ventilation buildings, a toll plaza in East Boston, six storm water pumping stations and three administration buildings. The limits of the Sumner/Callahan Tunnels are shown in Figure 2-3.

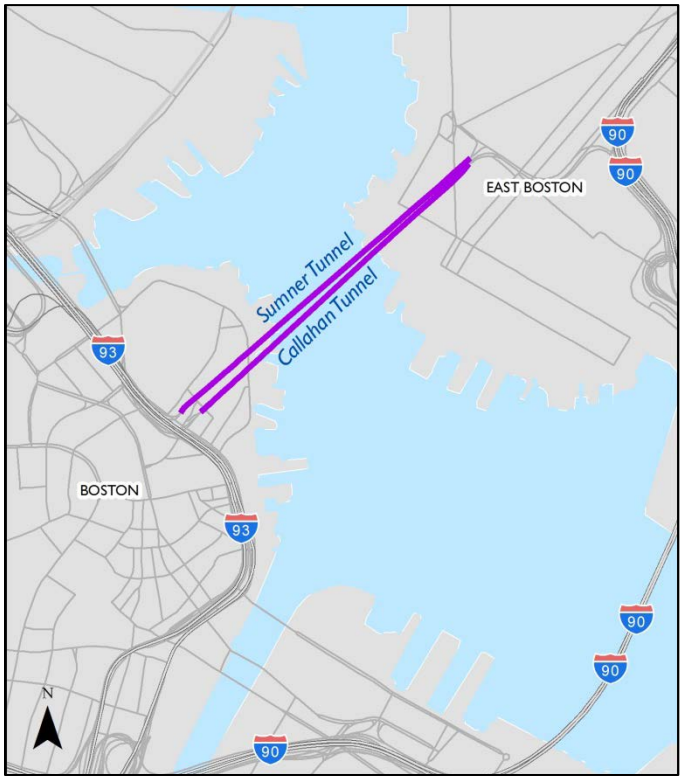

Figure 2-3 – Sumner and Callahan Tunnels

Central Artery North Area (CANA) Tunnel

The Central Artery North Area, which includes a tunnel system and other structures, carries US Route 1 and connects I-93 to the Tobin Bridge in Charlestown. The Central Artery North Area Tunnel was constructed in the 1980's.

Unlike the Sumner, Callahan and Ted Williams Tunnels, the CANA Tunnel was built using cut and cover construction techniques. The configuration of the CANA tunnel is different from the other tunnels in that it does not have a fresh air supply duct. Ventilation is provided solely by exhaust ducts located along the side of the tunnel. The exhaust from vehicles is drawn into the exhaust duct and moved through the exhaust vents by the fans in two ventilation buildings, one ventilation building for the northbound tunnel, Vent Building 15, and one for the southbound tunnel, Vent Building 14.

The combined length of the CANA tunnel (northbound and southbound) is 2,440 feet and includes two ventilation buildings and one storm water pumping station. Figure 2-4 shows the overall limits of the CANA Tunnel.

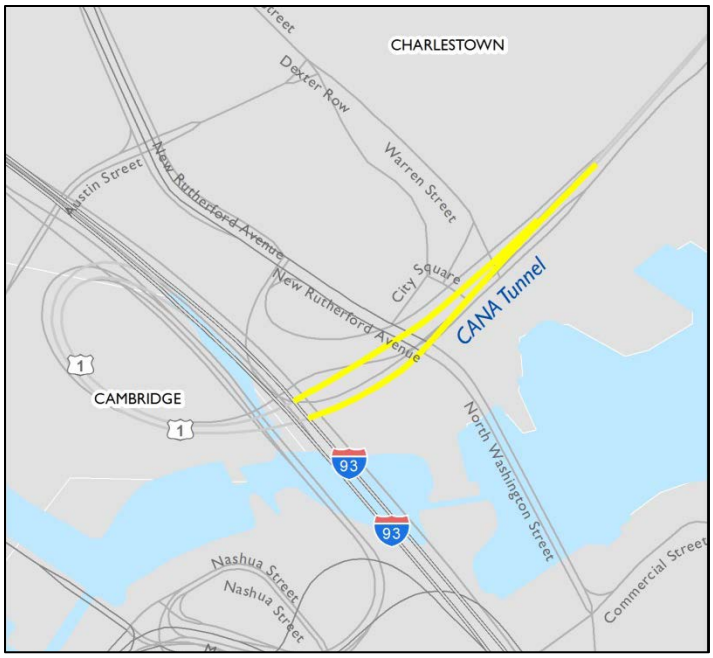

Figure 2-4 – Central Artery North Area Tunnel

Boston Extension

The Boston Extension is the portion of I-90 from, and including, the Route 128/I-95 interchange in Weston to the South Bay interchange (reconstructed as part of the Central Artery/Tunnel project) at I-93 in Boston. It extended the Initial Turnpike, which ended at Route 128, into Boston where it connects with I-93. This segment of the Turnpike has become known as the Boston Extension. Traffic began using this 12 mile section of the Massachusetts Turnpike toll road in September 1964.

The overall limits of the Boston Extension are shown in Figure 2-5. The Boston Extension is divided into the following five areas, from west to east:

- Weston (starting at Ridgeway Road, just west of the interchange with Route 128/I-95)
- Newton
- Brighton (including a short section in Brookline)
- Prudential Passageway (also referred to as the Prudential Tunnel) passes under the Prudential, Copley and Hancock private developments in the Back Bay area of Boston.
- Boston (ending at the point where the Boston Extension connects with the I-90/I-93 Interchange completed as part of the Central Artery/Tunnel project)

The Boston Extension has approximately 116 lane miles of roadway, all of which are toll road. It includes four storm water pumping stations, several toll facilities and four fan rooms within the Prudential Passageway.

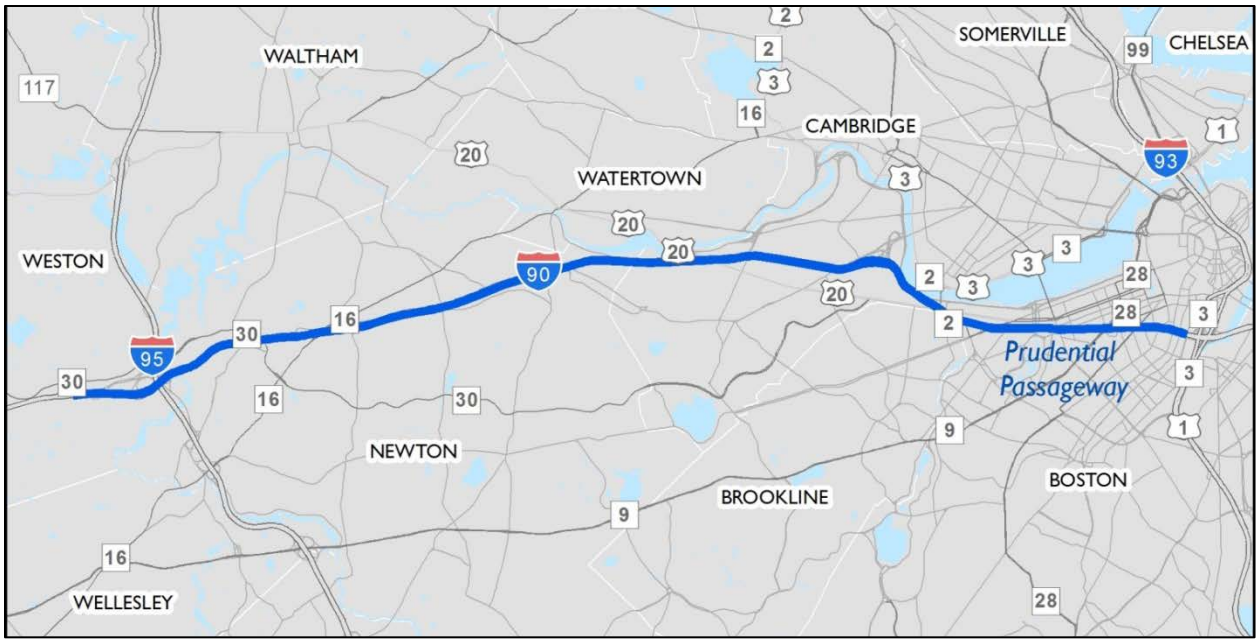

Figure 2-5 – Boston Extension

2.4 MHS Asset Classes

In the development of the 2015 Triennial Inspection and associated report, TranSystems has utilized the following nomenclature:

- *Asset Class* – Overall category of a type of Asset (i.e. Bridge, Tunnel, Building, etc.)
- *Asset* – Specific facility or structure (i.e. Bridge B-16-600 (9PM), Toll Plaza at Interchange 18, etc.)
- *Element* – Specific parts of an asset (i.e. a Bridge has Deck, Superstructure and Substructure elements. Toll Plaza has booth, canopy, equipment, etc.)

The MHS contains the following Asset Classes:

Bridges - There are 227 bridges in the MHS. These structures include numerous road and rail grade separated crossings over and under I-90 and I-93, a number of interchange ramp bridges, as well as the Zakim Bridge. Structure types and ages vary significantly throughout the system.

Tunnels/Boat Structures - There is a significant network of tunnels/boat structures in the MHS. These include the I-93 mainline tunnels as well as associated boat structures and ramps, the I-90 Connector, the CANA Tunnel, the Sumner and Callahan Tunnels and the Ted Williams Tunnel. These tunnels and boat structures are delineated into 228 sections with individual bridge identification numbers (BIN's) for each.

Prudential Passageway - The Prudential Passageway is a section of the Boston Extension that includes the roadway between Clarendon Street and Dalton Street in Boston. The passageway is a corridor that passes under a number of local streets and buildings including the Huntington Ave, Dartmouth Street,

the Prudential Center, portions of Copley Place and a 7-story parking garage. The corridor is comprised of several bridges and various structural elements that support the structures above. In addition to the roadway, the MBTA Framingham/Worcester Commuter Rail Line runs parallel to the corridor to the south. The corridor contains a variety of electrical and mechanical support systems for the roadway and the structures above. The Prudential Passageway is separated into eight sections, four on the eastbound roadway and four on the westbound roadway.

Admin/Service Buildings - There are six Administration/Service Buildings in the MHS. The facilities are comprised of several buildings that support operations in District 6. These buildings are located at 145 Havre Street, 128 North Street, Interchange 16, 145 London Street, 50 Massport Haul Road and 185 Kneeland Street.

Maintenance Facilities - There are three Maintenance Facilities in the MHS. The facilities are comprised of several buildings that support the maintenance and operations forces in District 6. The CA/T Satellite Maintenance Facility, located at 60 Bunker Hill Industrial Park, includes a vehicle maintenance garage, salt shed and an emergency response station. The Central Maintenance Facility includes a vehicle maintenance garage and a bulk salt storage facility. The third Maintenance Facility is located in Chelsea and is comprised of office space and a maintenance garage.

Vent Buildings - There are thirteen vent buildings located within the MHS. These are above grade structures that provide ventilation for the underground tunnel system.

Office/Retail Building - There is one Office/Retail Building in the MHS. It is located at 135 Blackstone St. (Parcel 7) in Boston. This building is located adjacent to the Parcel 7 parking garage and is integrated with Vent Building No. 4. The building houses the Registry of Motor Vehicles and the Boston Public Market.

Walls - There are three walls identified within the MHS. There are reinforced concrete retaining walls and metal bin retaining walls located at Interchanges 14, 20 and 22.

Sign Support Structures - There are 85 sign structures in the MHS and they are comprised of both overhead truss and cantilevered structures.

Salt Sheds - There are two assets within the MHS that are identified as a salt sheds. The first is located at Interchange 19 in Brighton and consists of a concrete knee wall with a steel frame and canvas top. The second is located at 60 Bunker Hill Industrial Park in Boston and consists of a single story concrete building.

Electrical/Mechanical Substation - There are three Electrical/Mechanical Substations on the MHS. Two of substations are part of the Central Artery/Tunnels and are generally located at both north and south extents of the artery. The other substation is part of the Boston Extension and is located at Interchange 19. Two of the Electrical/Mechanical Substations are housed in free standing structures and the third is located within a building housing MassDOT electricians and Emergency Response Station No. 4. The structures are comprised of CMU block with metal panel facades and concrete foundations. These structures house a variety of electrical and mechanical components.

Pump Stations - There are 40 pump stations in the MHS. The pump stations are typically at low points in the tunnel systems and areas with storm water concentrations and are designated as 'Low Point' pump

stations and 'Storm Water' pump stations. The pump stations are typically located in the tunnel or boat structures.

Fan Rooms - There are seven fan rooms located within the MHS. Four of them are located at the Prudential Passageway of Interstate 90, two are located at the I-90 Collector tunnel, and one is located near the south end of the Tip O'Neill Tunnel of Interstate 93 southbound.

Air Intake Buildings - There is one asset within the MHS that is identified as an air intake building. It is located at 257 Congress Street in Boston and is referred to as the Dewey Square Tunnel Air Intake Building.

Garages - There is one asset within the MHS that is identified as a garage. It is a parking garage located at 135 Blackstone Street (Parcel 7) in Boston. The garage is located above retail spaces and is integrated with Vent Building No. 4.

Communication Towers/Facilities - There are three assets identified within the MHS as Communication Towers/Facilities. There is one located near Riverside Road at Toll Plaza 3 of Interchange 15; one near 186 Webster Street, at the west end of Interchange 16; and one at Interchange 20.

Emergency Response Stations - There are four emergency response stations located within the MHS. One is located at the maintenance facility at 60 Bunker Hill Industrial Park in Charlestown. A second station is located at the southern end of the I-93 tunnel at 480 Albany Street. The remaining two stations are adjacent to the east and west portals of the Ted Williams Tunnel at 4 Harborside Drive and 100 Massport Haul Rd. respectively. These stations support the Massachusetts State Police operations.

Roadway Pavement – To be consistent with previous Triennial Reports, the pavement for the MHS has been organized into approximately 1,000 foot long sections resulting in 138 sections.

Roadway Assets - Consistent with previous Triennial Reports, the MHS roadway facilities have been organized into approximately 1,000 foot long sections resulting in 138 sections. The roadway asset class encompasses all roadway and roadside elements including guardrails, drop inlets, light standards, fencing, side slopes, edging, roadway signs, and median barriers.

Interchanges - There are nine interchanges in the MHS. The interchanges are along the I-90 in the Boston Extension. The furthest west interchanges (interchange 14 and 15) at Interstate 95 and Route 128 transition between the Western Turnpike corridor and the Boston Extension. The interchange furthest to the east connects the Boston Extension to I-93 and the Ted Williams Tunnel. The interchanges between connect local roads and state route to the Boston Extension. Similar to the mainline roadway, the interchanges are being broken into two asset classes: Interchange Pavement and Interchange Assets.

Toll Plazas - There are 11 toll plazas within the MHS. 4 are located at the Weston Tolls (Interchanges 14 and 15), 4 at the Allston/Brighton Tolls (Interchanges 18 and 20), 2 at the easternmost end of Interstate 90 westbound, and one the easternmost end of the Sumner Tunnel on Massachusetts Route 1A southbound.

Parks - There is one park, the London Street Park (Veterans Park) in East Boston, which is included within the limits of MHS.

A breakdown of the assets is shown in Table 2-3.

Assets Class	Total	2015 Insp. Sample Set
Bridges	227	53
Tunnels/Boat Structures	228	53
Prudential Passageway	8	8
Admin/Service Building	6	6
Maintenance Facilities	3	3
Vent Buildings	13	12
Office/Retail Buildings	1	1
Walls	3	3
Sign Support Structures	85	39
Salt Sheds	2	2
Electrical/Mechanical Substations	3	3
Pump Stations	40	27
Fan Rooms	7	7
Air Intake Building	1	1
Garages	1	1
Communication Towers/Facilities	3	3
Emergency Response Station	4	4
Roadway Pavement (1000' sections)	138	57
Roadway Assets (1000' sections)	138	57
Interchanges*	9	9
Toll Plazas	11	11
Parks	1	1

Table 2-3 – MHS Assets by Asset Class

* Interchanges have not been broken down into asset classes for this table since the specific quantities are unknown.

SECTION 3. INSPECTION METHODOLOGY

Since being transferred to MassDOT jurisdiction in 2009, several of the MHS asset classes, including bridges and pavement, have been incorporated into MassDOT routine inspection programs. As such, several asset classes, including bridges, sign structures and pavement are being inspected and assessed more frequently than the three year requirement stipulated in the bond covenants. In recognition of this, MassDOT instructed TranSystems to conduct an independent verification (QA) of a representative number of assets to confirm that the process and assessments which have been performed provide a reasonable assessment of the existing conditions.

For assets that had not been inspected since the previous triennial inspection, TranSystems was directed to perform a visual inspection on a representative sample of the total inventory of the asset class.

3.1 Sample Size

With the understanding that MassDOT's intent for the 2015 Triennial Inspection was to inspect a portion of the total number of assets in each asset class, a representative sample set of assets from each asset class was established for the triennial inspection program. (Note: In the interest of public safety, the representative sample set was modified to ensure that a large proportion of assets with the lowest ratings in previous inspections were included in the sample set). The asset class sample sets were calculated to achieve a 90% confidence level and a 10% margin of error. The confidence level is a measure of how certain it is that a sample accurately reflects the asset population within its margin of error. The margin of error in this case is a percentage that describes how closely the condition of the sample is to the "true value" in the asset population.

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+(\frac{z^2 \times p(1-p)}{e^2 N})}$$

Equation 3-1 – Sample Size Equation

Population Size = N
Margin of error = e
Z-score = z
Population proportion = p = .50
For a 90% confidence level, z = 1.65

3.2 Field Inspection Process

Similar to past triennial inspections, the 2015 inspections were performed as a visual inspection of the representative sample of assets in order to determine the general condition of the asset. The inspections were performed by two-person teams utilizing a tablet with a customized ESRI Data Collection Application to record condition information and gather GIS data points (Latitude/Longitude) of the asset. Digital photographs were also taken and stored with the ESRI Data Collection Application. The previous triennial inspection information was utilized by the inspection teams so that they could denote any changes in condition.

The approach to inspection of assets generally followed one of the three following approaches:

Bridges and Tunnels
The condition rating for bridge or tunnel assets was furnished by MassDOT from the 4D Bridge Management System. Crews visually verified the condition for the sample set of these assets by visiting the bridges and tunnels and reviewing the previous inspection report to validate the inspection process. Our verification effort was concentrated on bridges and tunnels that MassDOT or consultants other than TranSystems or our subconsultants had performed.

Buildings/Facilities
Buildings/Facilities were inspected from the exterior and interior from the ground or floor level, respectively. An overall condition rating for exterior and interior structural elements was based on visually inspecting the exterior and each interior room of the building/facility. An overall condition rating for the mechanical and electrical systems was based on visually inspecting each element of the system. No testing of the mechanical and electrical systems was performed as part of this inspection effort. Examples of specific assets in this class are police barracks, maintenance facilities, vent buildings, etc.

Roadway/Roadside Elements
Assets along the MHS right-of-way were inspected visually. Crews inspected assets and elements within a given section of roadway (1,000 ft. increments). An overall condition rating was assigned for each asset and element along the roadway right-of-way. Examples of assets and elements on the roadway are pavement, sign support structures, interchanges, guardrail, curbing, side slopes, pavement markings, delineators, signs, fencing, drop inlets, lighting, etc.

3.3 Condition Coding Scale

The past triennial inspections have used a modified version of the National Bridge Inspection Standards (NBIS) condition coding guide for all inspected assets not just for assessing the condition of the bridges and tunnels. For consistency and comparison with past condition coding, these guidelines were continued in 2015 and are presented in Table 3-1.

The visual inspections performed included elements of the asset including any electrical, mechanical, and plumbing, but did not include hands-on inspections or compliance verification with current codes or design.

Rating	Description
R	Removed
N	Not Applicable
H	Hidden/Inaccessible
UR	Under Repair
X	Unknown
9	Excellent Condition - *Newly constructed.*
8	Very Good Condition - *No problems noted; No repairs are required. Examples include but are not limited to concrete floors, walls or columns exhibiting sporadic hairline cracks (temperature and shrinkage), isolated areas of honeycombing on concrete surfaces, water/rust stains on parapets, etc.*
7	Good Condition - *Some minor problems noted. Potential exists for minor maintenance. Examples include but are not limited to replacing burnt out light bulbs, tightening loose nuts/bolts, patching pot holes, removing excessive water from drainage grates, touch up painting of surfaces, etc.*
6	Satisfactory Condition - *Structural elements show some minor deterioration. Potential exists for major maintenance. Examples include but are not limited to removing and replacing damaged section of safety rails, removing and replacing isolated areas of deteriorated concrete, removing deteriorated sections of fireproofing, cleaning and painting isolated areas of rusted structural steel, etc.*
5	Fair Condition - *All primary structural elements are sound but have minor section loss, measurable cracking or spalling. Potential exists for minor rehabilitation. Examples include but are not limited to removing and replacing isolated areas of deteriorated concrete beyond the layer of reinforcing steel, repairing cracks in concrete exceeding of 1/16" in width with epoxy crack injection, removing and replacing damaged drainage grates or guardrail, blast cleaning and painting significant areas of structural steel, etc.*
4	Poor Condition - *Advanced section loss to structural steel, deterioration or spalling of concrete, moderate traffic impact damage to guardrail, attenuators, overhead signs, etc. Potential exists for major rehabilitation. Examples include but are not limited to removing and replacing significant areas of deteriorated concrete and reinforcing steel, adding cover plates to structural steel exhibiting loss of section, slurry wall leak injection, removing and repaving sections of bituminous concrete pavement, removing and replacing sections of guardrail and attenuators damaged by traffic impacts, etc.*
3	Serious Condition - *Advanced deterioration has seriously affected primary structural components with the possibility of local failures. Fatigue cracks in steel, shear cracks in concrete, advanced seepage of water through walls, severe traffic impact damage to sections of guardrail, attenuators, overhead signs, etc. may be present. Repair or rehabilitation is required immediately.*
2	Critical Condition - *Advanced deterioration of primary structural elements. The need for rehabilitation is urgent. The facility should be closed until indicated repair is completed.*
1	"Imminent" Failure Condition - *Major deterioration or section loss is present in critical structural components or obvious vertical or horizontal movement is affecting stability. Facility is closed but corrective action may put it back in limited service. Study should be conducted to determine the feasibility for rehabilitation.*
0	Failed Condition - *Facility is closed and out of service. Facility is beyond corrective action.*

Table 3-1 – Condition Coding Scale

3.4 Asset Condition Data Collection

The two-person inspection teams utilized a tablet with a customized version of the ESRI Data Collection Application to record the condition information of each asset.

A data collection map was developed for each asset class that allowed inspectors to input information specific to each asset including the sub-elements of the asset (See Figure 3-1). The data input was similar to information that was gathered in previous triennial inspections in order to effectively compare condition data from previous years with the 2015 condition data.

Figure 3-1 - Screenshot of ESRI Data Collection Application developed for the Triennial Inspection

SECTION 4. SUMMARY OF FINDINGS

A full presentation of the conditions observed during field inspections is included in Appendix A-1. The following provides a brief summary of notable observations/evaluations encountered.

4.1 Bridges

Overall Condition Rating: *Satisfactory (6)*

Note: Inspections of MHS bridges are now incorporated into MassDOT's inspection program. This includes performing a routine inspection of each bridge at a minimum of every two years. Based on this fact, MassDOT determined that a full visual inspection of each bridge was not required as part of this Triennial Inspection Program. MassDOT directed TranSystems to conduct an audit inspection of a representative number of bridges (53). These "audit inspections" were done to verify the conditions noted in the routine reports. **The audit inspections confirmed that the MassDOT inspection process and reports were valid.**

These inspections noted a few changes to the structures since the last inspection including: recent repairs to various elements; structures that have recently been painted; and additional concrete deterioration of the deck and substructure. See Appendix A-1, Bridges, pgs. 1 - 54 for 2015 inspection audit forms and photos.

Based on the data provided by MassDOT, the three primary items in the Routine Inspection Report (i.e. Item 58 - Deck, Item 59 - Superstructure, and Item 60 - Substructure) are generally in satisfactory condition. See Appendix A-3 for bridge inspection reports printed from the MassDOT 4D bridge management system.

Overall Condition	*# of Assets*	*%*
Good	77	34%
Satisfactory	93	41%
Fair	46	20%
Poor	11	5%
Total	227	100.00%
Structurally Deficient (SD)	20	9%

There are twenty structures considered structurally deficient with one or more of the Items in poor conditions. There are fourteen structures with Item 58-Deck in poor condition, four structures with Item 59-Superstructure in poor condition, and six structures with Item 60-Substructure in poor condition as follows:

City/Town	Bridge	BIN	Deck (Item 58)	Super-Structure (Item 59)	Sub-Structure (Item 60)	Appendix A-3 (Pg. #)
Newton	N-12-014	4RB	5	4	4	6169-6248
Newton	N-12-027	4QW	4	6	5	5750-5791
Newton	N-12-065	4QL	4	6	5	5963-6000
Newton	N-12-069	4R7	7	6	4	6129-6148

City/Town	Bridge	BIN	Deck (Item 58)	Super-Structure (Item 59)	Sub-Structure (Item 60)	Appendix A-3 (Pg. #)
Newton	N-12-070	4R9	7	7	4	6149-6168
Weston	W-29-046	4QA	4	4	5	6269-6292
Weston	W-29-052	9YU	N	4	6	6374-6391
Weston	W-29-057	4QE	5	4	5	6462-6522
Boston	B-16-043	4TF	4	5	5	1-98
Boston	B-16-044	4TE	5	6	4	99-144
Boston	B-16-051	4T5	4	5	5	377-441
Boston	B-16-054	4T2	4	6	5	483-536
Boston	B-16-055	4T0	4	5	4	537-585
Boston	B-16-056	4RE	4	5	5	586-641
Boston	B-16-060	4RK	4	5	5	760-784
Boston	B-16-080	4RQ	4	6	5	1013-1062
Boston	B-16-216	4T1	4	6	5	1079-1131
Boston	B-16-359	4RX	4	5	5	1299-1398
Boston	B-16-359	4RY	4	5	5	1399-1526
Boston	B-16-369	4RT	4	5	4	1581-1647

4.2 Tunnels/Boat Structures

Overall Condition Rating: *Satisfactory (6)*

Note: Inspections of MHS tunnels/boat structures are now incorporated into MassDOT's inspection program. This includes performing a routine inspection of each tunnel/boat section at a minimum of every two years. Based on this information, MassDOT determined that a full visual inspection of each tunnel was not be required as part of this Triennial Inspection Program. MassDOT directed TranSystems to conduct an audit inspection of a representative number of tunnels (53). These "audit inspections" were done to verify the conditions noted in the routine reports. **The audit inspections confirmed that the MassDOT inspection process and reports were valid.**

See Appendix A-1, Tunnel/Boat Structures, pgs. 1 - 51 for 2015 inspection audit forms and photos.

Based on the data provided by MassDOT, the four primary items in the Routine Structures Inspection Report (i.e. 62a – Structural, 62b –Roadway, 62c – Ceiling Overhead and 62d – Air Ducts) are generally in satisfactory condition. See Appendix A-4 for tunnel inspection reports printed from the MassDOT 4D bridge management system.

Overall Condition	*# of Assets*	*%*
Good	31	14%
Satisfactory	167	73%
Fair	29	13%
Poor	1	<1%
Total	228	100%
Structurally Deficient (SD)	4	1.75%

However, there are four structures considered structurally deficient with one or more of these items in poor condition as follows:

City/Town	Tunnel	BIN	Structural (Item 62a)	Roadway (Item 62b)	Ceiling/ Overhead/ Exhaust (Item 62c)	Supply Air Duct (Item 62d)	Appendix A-4 (Pgs.)
Boston	B-16-233	A07	4	5	4	5	22-170
Boston	B-16-625	7GC	6	6	4	N	5110-5148
Boston	B-16-404	922	6	6	4	7	571-620
Boston	B-16-549	7JB	6	5	5	4	3081-3087

4.3 Prudential Passageway

Note: Inspections of Prudential Passageway are now incorporated into MassDOT's inspection program. This includes performing a routine inspection a minimum of every two years. Based on this information, MassDOT directed TranSystems to conduct an audit inspection of the Passageway. These "audit inspections" were done to verify the conditions noted in the routine reports. **The audit inspections confirmed that the MassDOT inspection process and reports were valid.**

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	*# of Assets*	*%*
Satisfactory	8	100%

See Appendix A-1, Prudential Passageway, pgs. 1 – 32 for 2015 inspection findings.

Typical conditions noted in the prudential passageway include: cracked concrete with efflorescence; scattered areas of missing fireproofing; spalled concrete with exposed rebar in the concrete walls; isolated tunnel lights not functioning; moderate rust to conduit supports and junction boxes with exposed wires.

4.4 Admin/Service Buildings

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	*# of Assets*	*%*
Satisfactory	5	83%
Fair	1	17%
Total	6	100%

See Appendix A-1, Administration Buildings, pgs. 1 – 51 of 299 for 2015 inspection findings.

Typical conditions noted to the admin/service buildings include: cracks on the walls, roof slab and floor; peeling paint; dents and corrosion to doors; and spalls to concrete surfaces.

4.5 Maintenance Facilities

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	3	100%

See Appendix A-1, Maintenance Facilities, pgs. 52 – 88 of 299 for 2015 inspection findings.

Typical conditions noted to the maintenance facilities building exteriors and surrounding sites include: cracked and broken brick and mortar joints; spalled and cracked concrete walls; minor collision damage to exterior walls; cracked concrete foundations; and overgrown vegetation. Typical conditions noted to the maintenance facilities building interiors include: peeling paint; dents and corrosion to doors; evidence of water leakage and water stains on ceiling tiles; cracks and spalling to concrete surfaces.

4.6 Vent Buildings

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	12	100%

See Appendix A-1, Vent Buildings, pgs. 89 – 214 of 299 for 2015 inspection findings.

Typical conditions noted to the vent buildings include: cracked, delaminated and spalled concrete walls and flues; leaks on the walls and ceiling below ground level; evidence of ceiling leaks above ground level; and deteriorated electrical and mechanical components.

4.7 Office/Retail Buildings

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	1	100%

See Appendix A-1, Office/Retail Buildings, pgs. 215 – 222 of 299 for 2015 inspection findings.

Typical conditions noted to the office/retail buildings include: evidence of water leaks through the roof; cracked and spalled precast beams; evidence of water leaks, rust staining and efflorescence on the walls; and cracks in the concrete floors.

4.8 Walls

Overall Condition Rating: *Fair (5)*

Overall Condition	# of Assets	%
Satisfactory	1	33.3%
Fair	1	33.3%
Poor	1	33.3%
Total	3	100.00%

See Appendix A-1, Walls, pgs. 1 – 18 for 2015 inspection findings.

Typical conditions noted to the concrete walls include: hairline cracks, small spalls and areas of exposed reinforcing steel. Typical conditions noted to the metal bin walls include areas of moderate to heavy rust with isolated areas of 100% section loss.

One metal bin wall, near Interchange 20, was found to be in poor condition with an element in serious condition. This metal bin wall exhibits large areas of 100% section loss, and the retained fill has spilled out onto the adjacent road.

4.9 Sign Support Structures

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Good	15	39%
Satisfactory	18	46%
Fair	6	15%
Total	39	46%

See Appendix A-1, Sign Support Structures, pgs. 1 – 39 for 2015 inspection findings.

Typical conditions noted to the sign support structures include: scattered areas of map cracking, scaling and spalling to the concrete foundations; light rust on the anchor bolts, nuts and washers; and light fading to sign text and reflectivity.

4.10 Salt Sheds

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	2	100%

See Appendix A-1, Salt Sheds, pgs. 223 – 231 of 299 for 2015 inspection findings.

The salt sheds are generally in satisfactory condition with minor deficiencies predominantly caused by vehicle impacts.

4.11 Electrical/Mechanical Substations

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	3	100%

See Appendix A-1, Electrical/Mechanical Substations, pgs. 232 – 250 of 299 for 2015 inspection findings.

Typical conditions noted to the electrical/mechanical substations include; vegetation growth on the surrounding site; and cracked and isolated spalls to exposed concrete surfaces.

4.12 Pump Stations

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Good	2	7%
Satisfactory	23	86%
Fair	2	7%
Total	27	68%

See Appendix A-1, Pump Stations, pgs. 1 – 146 for 2015 inspection findings.

Typical conditions noted to the pump stations include: cracked concrete with efflorescence to the walls, roof slab and floor; evidence of water leaks; areas of standing water; moderate to heavy corrosion with minor to moderate areas of section loss to mechanical/electrical components; oil leaking from mechanical components; and water leaking from components.

Three pumps are in poor condition, these pumps exhibit heavy corrosion, are not functioning and/or are missing.

4.13 Fan Rooms

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	7	100%

See Appendix A-1, Fan Rooms, pgs. 1 – 21 for 2015 inspection findings.

Typical conditions noted to the fan rooms include: evidence of water leaks from the first floor roof slabs; corner spalls and cracks in the concrete beams, columns, walls and floor slabs; and peeling paint, rust and corrosion on several fan housings.

4.14 Air Intake Building

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	1	100%

See Appendix A-1, Air Intake Buildings, pgs. 251 – 259 of 299 for 2015 inspection findings.

Typical conditions noted to the air intake building include: isolated cracked granite facing on the exterior façade; dislodged louver screens on the west side of the building; and an area of 1/4" deep standing water in fire pump room.

4.15 Garage

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	1	100%

See Appendix A-1, Garage, pgs. 260 – 267 of 299 for 2015 inspection findings.

Typical conditions noted to the garage include: hairline cracks with efflorescence on the topside and underside surfaces of the structural concrete decks (which are integral with the beams); minor spalling along the deck joints; missing or displaced joint material; diagonal hairline cracks at the dapped end of concrete beam stems; full-height vertical hairline cracks about 2' from the dapped end of the beams; and horizontal, vertical, and diagonal hairline cracks on the columns. The stairway risers typically exhibit peeling paint and heavy corrosion, with an isolated risers exhibiting advanced corrosion in the south stairwell between levels 1 and 2.

4.16 Communication Towers/Facilities

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Good	1	33.3%
Satisfactory	2	66.7%
Total	3	100%

See Appendix A-1, Communication Towers/Facilities, pgs. 1 – 3 for 2015 inspection findings.

Typical conditions noted to the communication towers/facilities include: hairline cracks and minor spalls of the walls of the buildings and heavy vegetation growth around the perimeter of the buildings. The interiors of the buildings generally have minor deficiencies such as peeling paint, broken doors.

4.17 Emergency Response Stations

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	4	100%

See Appendix A-1, Emergency Response Stations, pgs. 268 – 299 of 299 for 2015 inspection findings.

Typical conditions noted to the emergency response stations include: cracked concrete, and broken and cracked bricks on the exterior facade.

4.18 Roadway Pavement

Overall Condition Rating: *Good (7)*

MassDOT conducts routine assessments of roadway pavement utilizing and in-house semi-automated collection system. During the timeframe of the triennial inspection effort MassDOT collected pavement condition data for the Boston Extension. The complete results from this assessment are included in Appendix A-5 and summarized here.

	Westbound		Eastbound	
Condition	*Lane Miles*	*%*	*Lane Miles*	*%*
Excellent	27	66%	16	37%
Good	5	11%	14	33%
Fair	5	11%	9	20%
Poor	5	12%	4	10%
Total	42	100%	43	100%

TranSystems conducted an independent inspection of the roadway pavement condition while inspecting the roadway assets. **It was confirmed that the MassDOT pavement inspection process was valid by comparing the MassDOT data and our data.**

See Appendix A-1, Roadway, pgs. 1 – 120 for 2015 inspection findings.

It should be noted that the pavement condition identified as part of this asset class does not include the pavement within the tunnel system. Evaluation of pavement elements within the tunnel system is included as part of the Tunnels/Boat Sections Asset Class.

4.19 Roadway Assets

Overall Condition Rating: *Satisfactory (6)*

A sample size of 57 sections of roadway was inspected as part of this Triennial Inspection effort. Elements inspected as part of this asset class include guardrail, barrier, pavement markings, catch basins, light standards, roadway signs, fencing, edging, and side slopes. See Appendix A-1, Roadway, pgs. 1 – 120 for 2015 inspection findings.

Guardrail - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for the guardrail include: areas of minor to heavy collision damage and areas of light to moderate rust.

Pavement Markings - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for the pavement markings include: worn, chipped and faded markings.

Drop Inlets - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for the catch basins include: partially to completely clogged grates and spalling of concrete around frame of grate.

Light Standards - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for light standards include: broken/missing lights, minor collision damage and missing hand hole covers.

Fencing - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for the fencing include: light to moderate rust on the posts and chain link; damaged posts and chain link; and vegetation/debris across fence.

Side Slope - Overall Condition Rating: Good Condition (7)
Typical conditions noted for the side slope include: heavy vegetation growth; minor to moderate erosion; debris within paved waterways; and erosion around the paved waterways.

Edging - Overall Condition Rating: Good Condition (7)
Typical condition noted for the edging includes: minor settlement at isolated locations.

Roadway Signs - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for the roadway signs include: minor collision damage; cracking of sign panel; and fading of the sign.

Barriers - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for the concrete median barrier include: spalling with exposed reinforcing steel; cracks in the concrete; and collision damage.

4.20 Interchange Pavement

Overall Condition Rating: *Fair (5)*

See Appendix A-1, Interchanges, pgs. 1 – 62 for 2015 inspection findings.

Typical conditions noted for the interchange roadway pavement include: map cracking, pot holes, and patches.

4.21 Interchange Assets

Overall Condition Rating: *Fair (5)*

See Appendix A-1, Interchanges, pgs. 1 – 62 for 2015 inspection findings.

Generally the roadway assets of the interchanges rate between Fair to Satisfactory. Inspections conducted as part of this asset class included an assessment of the following elements: guardrail, barrier, drop inlets, light standards, curbing, edging and side slopes.

Guardrail - Overall Condition Rating: Fair Condition (5)
Typical conditions noted for the guardrail include: areas of minor to moderate collision damage.

Barrier - Overall Condition Rating: Satisfactory Condition (6)
Typical conditions noted for the barrier include: shallow spalls, map cracks; vegetation growth at base; and collision damage.

Drop Inlets - Overall Condition Rating: Fair Condition (5)
Typical conditions noted for the drop inlets include: partially to completely clogged grates and spalling of concrete around frame of grate.

Light Standards - Overall Condition Rating: Fair Condition (5)
Typical conditions noted for the light standards include: missing anchor bolt covers; loose hand access panels; cracking/spalling of the concrete bases; and non-functioning lights.

Curbing - Overall Condition Rating: Fair Condition (5)
Typical conditions noted for the curbing include: chipping of edges; minor settlement at isolated locations; minor misalignment; and vegetation growth at the joints.

Edging - Overall Condition Rating: Fair Condition (5)
Typical conditions noted for the edging include: minor settlement at isolated locations and vegetation growth.

Side Slope - Overall Condition Rating: Fair Condition (5)
Typical conditions noted for the side slope include: minor areas of poor cover; and minor erosion.

4.22 Toll Plazas

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	*# of Assets*	*%*
Satisfactory	10	91%

See Appendix A-1, Toll Plazas, pgs. 1 - 99 for 2015 inspection findings.

The toll plazas typically exhibit cracks and spalls to the concrete islands and pavement around them. There is corrosion, peeling paint and rust on the canopies, primarily at the bases. Ceilings and floors of various rooms and personnel tunnels exhibit signs of leakage and have missing/broken tiles.

4.23 Parks

Overall Condition Rating: *Satisfactory (6)*

Overall Condition	# of Assets	%
Satisfactory	1	100%

See Appendix A-1, Parks, pg. 1 for 2015 inspection findings.

The overall condition of the Park is considered to be Satisfactory with a few minor deficiencies. There is a missing light fixture housing with the light bulb exposed at the northeast entrance to the park. Additionally, the brick capitals exhibit minor cracking of the mortar joints and small spalls in the concrete caps.

SECTION 5. STATE OF GOOD REPAIR

MassDOT's goal is to maintain the assets of the Metropolitan Highway System (MHS) in a State of Good Repair in an effort to sustain asset reliability and safety for the long-term benefit of the Commonwealth. A state of good repair is achieved when performance measure targets are met and sustained. When this is achieved, the assets (individually and as a system) are functioning properly over their life-cycle at minimum practical cost.

The current condition state of each asset is time dependent and fleeting depending upon asset specific deterioration rates. Performance measure targets are asset dependent and established by the owner. Two performance targets are presented in this report: short-term goal (5 years); and long-term goal (20 years). Minimal practical cost is achieved upon careful execution and coordination of regular planned maintenance strategies, asset preservation actions, implemented repair and rehabilitation programs, and even consideration of complete replacement of the asset when prudent.

The following short and long term performance measures were developed for the MHS inventory of assets. These performance measures may differ from the statewide performance measures because of the importance of this corridor to statewide travel as well as its classification as an interstate highway.

5.1 Bridges

A State of Good Repair is achieved when the physical condition of the bridge elements, components, and entire bridges are functioning properly and sustained through regular maintenance, preservation, and replacement actions. The performance measures for bridges include both short-term and long-term goals for the following parameters: overall condition rating; structural deficiency; and bridge health index.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	90%
Structurally Deficient*	< 10% (SF of deck area)	0% = no SD Bridges
Health Index	80%	90%

* Statewide Long Term Goal: <3% structurally deficient

5.2 Tunnels/Boat Sections

A State of Good Repair is achieved when the physical condition of the tunnel elements, components, and entire tunnels are functioning properly and sustained through regular maintenance, preservation, and replacement actions. The performance measure for tunnels also includes both short-term and long-term goals for the following parameters: overall condition rating; structural deficiency; tunnel health index; and leak condition rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	90%
Structurally Deficient	< 10% (SF of tunnel plan area)	0% = no SD Tunnels
Health Index	80%	90%
Leak Condition Rating ≥ 6	90%	100% = no Significant Leaks

5.3 Pavement

A State of Good Repair is achieved when the physical condition of the pavement is fairly smooth and sustained through regular maintenance, preservation, and replacement actions. The performance measures for pavement includes both short-term and long-term goals for the following parameters: overall condition rating; and international roughness index.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	90%
International Roughness Index < 120	90% in smooth / good riding quality	100% = smooth / good riding quality

5.4 Maintenance Facilities

A State of Good Repair is achieved when the physical condition of the maintenance facility is in overall Satisfactory Condition. This condition is achieved when the maintenance facility building exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for each maintenance facility includes both short-term and long-term goals for the following parameter: overall condition rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.5 Vent Buildings

A State of Good Repair is achieved when the physical condition of the vent building is in overall Satisfactory Condition. This condition is achieved when the building exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for vent buildings includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.6 Office/Retail Buildings

A State of Good Repair is achieved when the physical condition of the office / retail building is in overall Satisfactory Condition. This condition is achieved when the building exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for office / retail building includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.7 Walls

A State of Good Repair is achieved when the physical condition of the wall is in overall Satisfactory Condition. This condition is achieved when the wall elements are functioning properly, are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for each wall includes both short-term and long-term goals for the following parameters: overall condition rating; and structurally deficient.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	90%
Structurally Deficient	< 10% (LF of wall length)	0% = no SD Walls

5.8 Sign Support Structures

A State of Good Repair is achieved when the physical condition of the sign support structure is in overall Satisfactory Condition. This condition is achieved when the sign support elements are functioning properly, are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for sign support structures includes both short-term and long-term goals for the following parameters: overall condition rating; and structurally deficient.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	90%
Structurally Deficient	< 10% (# of sign support structures)	0% = no SD Sign Support Structures

5.9 Salt Sheds

A State of Good Repair is achieved when the physical condition of the salt shed is in overall Satisfactory Condition. This condition is achieved when the salt shed exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for salt sheds includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.10 Electrical/Mechanical Substations

A State of Good Repair is achieved when the physical condition of the electrical/mechanical substation is in overall Satisfactory Condition. This condition is achieved when the substation exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for electrical/mechanical substation includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.11 Pump Stations

A State of Good Repair is achieved when the physical condition of the pump station is in overall Satisfactory Condition. This condition is achieved when the pump station mechanical, electrical, and structural systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for pump stations includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.12 Fan Rooms

A State of Good Repair is achieved when the physical condition of the fan room is in overall Satisfactory Condition. This condition is achieved when the fan room mechanical, electrical, and structural systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for fan rooms includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.13 Air Intake Buildings

A State of Good Repair is achieved when the physical condition of the air intake building is in overall Satisfactory Condition. This condition is achieved when the air intake building exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for air intake buildings includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.14 Admin/Service Buildings

A State of Good Repair is achieved when the physical condition of the admin/service building is in overall Satisfactory Condition. This condition is achieved when the admin/service building exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for admin/service building includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.15 Garages

A State of Good Repair is achieved when the physical condition of the garage is in overall Satisfactory Condition. This condition is achieved when the garage exteriors, roof(s), interiors, and any mechanical, hydraulic, and/or electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for garages includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.16 Communication Towers/Facilities

A State of Good Repair is achieved when the physical condition of the communication facility is in overall Satisfactory Condition. This condition is achieved when the access road, area perimeter, building exterior(s), roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for each communication facility includes both short-term and long-term goals for the following parameter: overall condition rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.17 Emergency Response Stations

A State of Good Repair is achieved when the physical condition of the emergency response station is in overall Satisfactory Condition. This condition is achieved when the building exteriors, roof(s), interiors, and mechanical and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for emergency response stations includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.18 Roadway Assets

A State of Good Repair is achieved when the physical condition of the roadway is in overall Satisfactory Condition. This condition is achieved when the roadway elements are functioning properly, are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for roadway includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80% (Lineal Miles of Highway)	100%

5.19 Interchange Assets

A State of Good Repair is achieved when the physical condition of the interchange is in overall Satisfactory Condition. This condition is achieved when the assets on the interchange ramps, and any maintenance, parking, and/or trailer areas are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for interchanges includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

5.20 Parks

A State of Good Repair is achieved when the physical condition of the park is in overall Satisfactory Condition. This condition is achieved when the park grounds, appurtenances, monuments, and electrical systems are in no less than fair condition and sustained through regular maintenance, preservation, and replacement actions. The performance measure for parks includes both short-term and long-term goals for the following parameter: Overall Condition Rating.

Performance Measure	Short-Term Goal	Long-Term Goal
Overall Condition Rating ≥ 6	80%	100%

SECTION 6. STATE OF GOOD REPAIR ACTION PLAN

6.1 Introduction

Based upon finding of conditions and the State of Good Repair (SGR) goals set forth in Section 5 of this report, a SGR Action Plan has been developed to maintain the assets of the Metropolitan Highway System in a State of Good Repair for the next 20 years. This SGR Action Plan details the activities necessary to restore and/or maintain the assets of the MHS in a State of Good Repair. These activities include the performance of a comprehensive and consistent program of routine maintenance (performed annually) as well as scheduled preventative maintenance (performed on a multi-year cycle to the extent required). These routine and preventative maintenance activities are required to maintain assets which are in satisfactory or better condition. The SGR Action Plan also includes certain capital projects to further improve ore replace assets when necessary. The activities for each asset class are presented in Appendix A-6 *Projected Future Expenditures.*

6.2 Action Plan Recommendations

The activities for routine maintenance, scheduled preventative maintenance, rehabilitation/replacement and other planned construction activities vary by asset class. The following presents the recommended Action Plan discussed by asset class. It should be noted that MassDOT has provided a separately developed list of capital projects identified to occur over the next five years. While TranSystems has developed a recommended SGR Action Plan independent of MassDOT's anticipated expenditures, we have reconciled the SGR Action Plan with MassDOT's proposed program and incorporated the elements of MassDOT's program to avoid overlapping activities.

6.2a Bridges

There are a total of 227 bridges on the MHS. The bridge inventory includes a wide range of complex steel and concrete structure types.

For development of the SGR Action Plan, bridges were categorized by their current average condition rating, calculated by taking the average of the deck condition rating (Item 58), superstructure condition rating (Item 59), and substructure condition rating (Item 60). Bridges with an average condition rating greater than or equal to six (6) can be maintained in their current condition through the following activities:

- Routine maintenance, consisting of: asphalt pavement crack sealing and patching; drain/scupper cleaning; power washing superstructure and substructure areas below deck joints. This work is required annually to prevent the onset of deterioration to bridge structural members and safety elements.
- Scheduled preventative maintenance, consisting of: deck patching, deck joint gland replacement; wearing surface and membrane replacement; steel superstructure cleaning and painting; concrete substructure patching and crack repair. This work is required every 12 years to replace consumable elements which protect the bridge structure, and to arrest any areas of deterioration which may exist.

There are 20 bridges that are structurally deficient. Based on their current condition, rehabilitation or replacement is recommended within the next five years. Additionally, after the bridge rehabilitation or replacement has occurred these bridges will require annual routine maintenance, and scheduled preventative maintenance every 12 years.

6.2b Tunnels/Boat Structures

The MHS contains a network of tunnels and boat structures that are divided and tracked as 228 sections.

For development of the SGR Action Plan, the tunnels were categorized by the current average condition of the primary items: structural, roadway, ceiling overhead, and air ducts. Tunnels where the overall average condition rating is satisfactory (6) with no individual element condition is less than fair (5) can be maintained in their current condition through the following activities:

- Routine Maintenance, consisting of: asphalt pavement crack sealing and patching, scupper/drain cleaning, debris removal, leak patching, mechanical/electrical maintenance for the lighting and ventilation systems. This work is required annually to prevent the onset of deterioration to tunnel structural members and safety elements.
- Scheduled Preventative Maintenance, consisting of: wearing surface and membrane replacement; tile repair/replacement; concrete structure patching and crack repair. This work is required every 12 years to replace consumable elements which protect the tunnel structure, and to arrest any areas of deterioration which may exist.

6.2c Maintenance Facilities

There are three maintenance facilities on the MHS. Each maintenance facility is composed of a variety of building structures with associated paved roads/driveways/parking lots, drainage, lighting and site vegetation. The structures range from administrative buildings to garages, storage buildings, emergency response stations and salt sheds.

For development of the SGR Action Plan, maintenance facilities were categorized by the current average condition of the building elements: exteriors, roofs, interiors and mechanical and electrical systems. Currently, all maintenance facilities have an overall average condition rating greater of satisfactory (6) with no individual element condition less than fair (5). These maintenance facilities can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the building(s) exterior, interior and mechanical/electrical/plumbing systems.
- Site maintenance, consisting of vegetation control and asphalt patching and/or crack sealing.

6.2d Vent Buildings

There are thirteen vent buildings on the MHS. Vent buildings typically consist of a building structure which houses mechanical/electrical/plumbing systems, and associated paved driveways/parking lots.

For development of the SGR Action Plan, the vent buildings were categorized by the current average condition of the building elements: exteriors, roofs, interiors and mechanical, electrical and plumbing systems. Currently, all vent buildings have an overall average condition rating of satisfactory (6) with no

individual element condition less than fair (5). These vent buildings can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the building(s) exterior, interior and mechanical/electrical/plumbing systems.
- Site maintenance, consisting of vegetation control and asphalt patching and/or crack sealing.

6.2e Office/Retail Buildings

There is one office/retail building on the MHS. For development of the SGR Action Plan, the office/retail building was categorized by the current average condition of the building elements: exterior, roof, interior and mechanical and electrical systems. Currently, the one office/retail buildings has an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). The office/retail building can be maintained in its current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the building(s) exterior, interior and mechanical/electrical/plumbing systems.

6.2f Communication Towers/Facilities

There are three communications towers/facilities on the MHS. These facilities contain a service building which houses electrical components, access road and site vegetation.

For development of the SGR Action Plan, the communication towers/facilities were categorized by the current average condition of the area perimeter and building elements: exteriors, roofs, interiors and mechanical and electrical systems. Currently, all facilities have an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). The communication facilities can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the building(s) exterior, interior and mechanical/electrical/plumbing systems.
- Site maintenance, consisting of vegetation control and roadway maintenance (asphalt patching and/or crack sealing, or, leveling for gravel roads).

6.2g Toll Plazas

There are 10 toll plazas on the MHS. These plazas are programmed for removal under an upcoming MassDOT project and therefore are not recommended for any significant rehabilitation effort. A new All-Electronic Tolling System (AETS) is programmed for installation under an upcoming MassDOT project.

6.2h Walls

There are three walls on the MHS. This total includes metal bin walls and reinforced concrete walls.

For development of the SGR Action Plan, walls were categorized by the current average condition of the wall elements. Walls where the overall average condition rating of satisfactory (6) with no individual element condition less than fair (5) can be maintained in their current condition through the following activities:

- Site maintenance, consisting of vegetation control on an annual basis.

There is one reinforced concrete wall which is currently in fair condition which requires repair, and one metal bin wall which is currently in poor condition which requires replacement.

6.2i Sign Support Structures

There are 85 sign support structures on the MHS. These structures are of steel construction and consist of overhead sign bridges (e.g. two supports) and cantilevers (e.g. one support).

The current MassDOT program includes removal and replacement of all sign support structures by 2018. The cost of this work is included in the Capital Program under Category 1 Modernization.

It is assumed that these new sign support structures will be in a state of good repair upon their installation. These sign support structures can be maintained in a state of good repair through performance of the inventory inspections.

6.2j Salt Sheds

There are two salt sheds on the MHS. One is a steel frame with a canvas top, and the other salt shed is a concrete building.

For development of the SGR Action Plan, the salt sheds were categorized by the current average condition of the site and the building elements: exteriors, roofs, and interiors. Currently, both salt sheds have an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). These salt sheds can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the building(s) exterior, interior and mechanical/electrical/plumbing systems.
- Site maintenance, consisting of vegetation control and asphalt patching and/or crack sealing.

6.2k Electrical/Mechanical Substations

There are three electrical/mechanical substations on the MHS. Each substation is composed of a building structure which houses mechanical/electrical/plumbing systems, and with associated paved driveways/parking lots.

For development of the SGR Action Plan, the electrical/mechanical substations were categorized by the current average condition of the site and building elements: exteriors, roofs, interiors and mechanical, electrical and plumbing systems. Currently, all electrical/mechanical substations have an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). These substations can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the building(s) exterior, interior and mechanical/electrical/plumbing systems.
- Site maintenance, consisting of vegetation control and asphalt patching and/or crack sealing.

6.2l Pump Stations

There are 40 pump stations on the MHS. The pump stations are typically is composed of a room which houses mechanical/electrical systems.

For development of the SGR Action Plan, the pump stations were categorized by the current average condition of the structural, mechanical, and electrical systems. Pump stations where the overall average condition rating is greater than satisfactory (6) with no individual element condition less than fair (5) can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the structural, mechanical, and electrical systems.

There are three pump stations with a condition rating of five (5) due to deterioration of the building and/or pumps. These pump stations require rehabilitation.

6.2m Fan Rooms

There are seven fan rooms on the MHS. Each fan room is composed of a building structure which houses mechanical and electrical systems.

For development of the SGR Action Plan, the fan rooms were categorized by the current average condition of the structural, mechanical and electrical systems. Currently, all fan rooms have an overall average condition rating of ssatisfactory (6) with no individual element condition less than fair (5). These fan rooms can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the structural, mechanical, and electrical systems.

6.2n Air Intake Building

There is one air intake building on the MHS. This asset is composed of a building structure which houses mechanical, electrical and plumbing systems, and has exterior vegetated areas.

For development of the SGR Action Plan, the air intake building was categorized by the current average condition of the site and building elements: exterior, roof, interior and mechanical, electrical and plumbing systems. Currently, the air intake building has an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). This building can be maintained in its current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the structural, mechanical, and electrical systems.
- Site maintenance, consisting of vegetation control.

6.2o Administration/Service Buildings

There are six Administration/Service Buildings in the MHS. These assets are composed of a building structure which houses various workspace environments, associated mechanical, electrical and plumbing systems, and exterior vegetated areas.

For development of the SGR Action Plan, the administration/service buildings were categorized by the current average condition of the site and building elements: exterior, roof, interior and mechanical, electrical and plumbing systems. Currently, five administration/service buildings have an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). These buildings can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the structural, mechanical, and electrical systems.
- Site maintenance, consisting of vegetation control.

One administrative/service building is in overall fair (5) condition. This building can be upgraded to satisfactory (6) condition through the building maintenance activities described above.

6.2p Garage

There is one garage on the MHS. This asset is a three-level concrete building structure.

For development of the SGR Action Plan, the garage was categorized by the current average condition of the building elements: exterior, roof, and interior. Currently, the garage has an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). This garage can be maintained in its current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the structure.

6.2q Emergency Response Stations

There are four emergency response stations on the MHS. These stations are composed of a building structure which houses mechanical, electrical and plumbing systems.

For development of the SGR Action Plan, the emergency response stations were categorized by the current average condition of the building elements: exterior, roof, interior and mechanical, electrical and plumbing systems. Currently, all emergency response stations have an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). These stations can be maintained in their current condition through the following activities:

- Building maintenance, consisting of regular, annual maintenance of the building exterior, interior and mechanical/electrical/plumbing systems.
- Site maintenance, consisting of vegetation control.

6.2r Roadway Pavement

The MHS consists of a total of 138 – 1,000 foot long sections of roadway, including at grade highways and at grade local roadways.

For development of the SGR Action Plan, the roadway pavement was evaluated on the pavement condition. Based on the results of pavement condition data recently collected by MassDOT, 77% of the Westbound lane miles and 70.0% of the Eastbound lane miles have a pavement condition of good (7) or greater. This pavement can be maintained in its current condition through the following activities:

- Pavement maintenance, consisting of annual patching and crack sealing of the asphalt pavement, as required.
- Pavement replacement, consisting of milling and repaving the overlay pavement. This work is to be performed every 12 years.

The remaining lane miles have an overall condition of fair (5) or less. The condition of this pavement can be improved to good (7) or greater through milling and paving within the next 4 years.

6.2s Roadway Assets

The MHS consists of a total of 138 – 1,000 foot long sections of roadway, including at grade highways and at grade local roadways. The roadway assets consist of: guardrail, median barrier, pavement markings, catch basins, light standards, roadway signs, fencing, edging, and side slope. These assets were evaluated over 57 sections of roadway.

For development of the SGR Action Plan, the roadway assets were evaluated on the current average condition of all roadway assets (guardrail, median barrier, pavement markings, catch basins, light standards, roadway signs, fencing, edging, and side slope). These roadway assets all have an overall average condition of satisfactory (6) with no individual element condition less than fair (5) based on the sample inspected for this triennial report. These roadway assets can be maintained in their current condition through the following activities:

- Routine highway maintenance, consisting of guardrail repairs, median barrier repairs, replacing line striping and delineators, attenuator repairs, mowing, vegetation maintenance, snow and ice removal, trash and roadside removal, side slope maintenance, and drainage maintenance as required.
- Highway element replacement, to be performed as necessary in conjunction with pavement replacement every 12 years.

6.2t Interchange Pavement

There are nine interchanges on the MHS. These range from small interchanges with state routes to complex multi-ramp interchanges with other interstate highways.

For development of the Capital Program, the interchange pavement was evaluated by the current average pavement condition. Currently, the interchange pavement has an overall average condition of fair (5). The interchange pavement can be improved to achieve state of good repair goals through the following activities:

- Pavement maintenance, consisting of annual patching and crack sealing of the asphalt pavement as required.
- Pavement replacement, consisting of milling and repaving the overlay pavement as required. This work is to be performed every 12 years.

6.2u Interchange Assets

There are nine interchanges on the MHS. These range from small interchanges with state routes to complex multi-ramp interchanges with other interstate highways.

For development of the Capital Program, the interchange assets were categorized by the current average condition of all interchange assets (guardrail, median barrier, catch basins, light standards, roadway signs, curbing, edging, and side slope). Currently, all interchange assets have an overall average condition of satisfactory (6) and no individual asset condition is less than fair (5). These interchange assets can be maintained in their current condition through the following activities:

- Routine highway maintenance, consisting of guardrail repairs, median barrier repairs, attenuator repairs, mowing, line striping and delineator maintenance, vegetation maintenance, snow and ice removal, trash and roadside removal, side slope maintenance, and drainage maintenance as required.
- Highway element replacement, to be performed as necessary in conjunction with pavement replacement every 12 years.

6.2v Prudential Passageway

The prudential passageway of the MHS is the section of the I-90 Boston Extension between Clarendon Street and Dalton Street in Boston, in a corridor below the Prudential Center and local streets. This passageway is divided into 8 sections.

For development of the SGR Action Plan, the prudential passageway sections were categorized by the current average condition of the structural elements, roadway elements and mechanical/electrical systems. Currently, the Prudential Passageway has an overall average condition of satisfactory (6) with no individual structural element condition less than fair (5). These passageway sections can be maintained in their current condition through the following activities:

- Routine maintenance, consisting of: drain/scupper cleaning; power washing superstructure and substructure areas below deck joints. This work is required annually to prevent the onset of deterioration to structural members and safety elements.
- Scheduled preventative maintenance, consisting of: deck joint gland replacement; steel superstructure cleaning and painting; fireproof covering repair; concrete wall patching and crack repair, and MEP component maintenance. This work is required every 12 years to replace consumable elements and to arrest any areas of deterioration which may exist.

6.2w Parks

There is one park within the MHS, London Street Park in East Boston.

For development of the SGR Action Plan, the park was categorized by the current average condition of the site, structural and electrical elements. Currently, the park has an overall average condition rating of satisfactory (6) with no individual element condition less than fair (5). The park can be maintained in its current condition through the following activities:

- Structure maintenance, consisting of regular, annual maintenance of the park structures and electrical system.

- Site maintenance, consisting of vegetation control, debris and graffiti removal.

6.3 Initial Five Year Action Plan

Major work items identified for the initial five year time period include:

- Replacement of all structural sign supports on the Boston Extension
- Initiation of all electronic tolling including installation of AETS facilities and removal of the existing toll plazas
- Installation of Real Time Traffic Monitoring
- Replacement of Structure 9 (I-90 over I-95 and the Charles River) and associated work
- Reconstruction of the Allston Interchange including replacement of Structure 111
- Replacement or rehabilitation to the following bridges on the Boston Extension:

Bridges

A review of existing conditions reveals 8 bridges that are recommended for replacement or significant rehabilitation in the initial five year period. These bridges are:

Municipality	BIN	Feature Intersected	Facility Carried
Weston	4QA	MDC Aqueduct	Ramps J & L
Newton	4RB	CSX/MBTA RR	I 90
Boston	4RE	I-90 & MBTA/CSX	Cambridge St.
Boston	4T5	I-90 & MBTA/CSX	Mass. Ave.
Boston	4TF	I-90 & AMTRAK	Tremont St.
Boston	4T2	I-90 & MBTA/CSX	Beacon St.
Boston	4TE	I-90 & AMTRAK	Arlington St.
Weston	9YU	DCR Aqueduct	Ramp C

Construction Remediation Contracts

In addition to the major work items listed above, a number of Central Artery/Tunnel related remediation work items have been identified. These projects are categorized separately as Construction Remediation Contracts (CRC). A listing of identified CRC projects with associated costs is included in Appendix A-6.

It is anticipated that with completion of these major work items along with implementation of a routine maintenance program the Western Turnpike will meet the criteria of State of Good Repair as defined previously in this Report by the end of the initial five year period.

Walls

A section of the metal bin retaining wall at Interchange 14, Ramp C has areas with section loss that have failed, and requires replacement. This work should be initiated as soon as possible. Additionally, a concrete retaining wall at Interchange 18-19-20, Ramp D has areas of cracking, spalling and settlement. This wall should be considered for rehabilitation.

Sign Support Structures
All sign support structures are programmed to be replaced within the Initial Five Year Plan period. These costs are reflected in the Initial Five Year Action Plan.

Pump Stations
The Callahan pump station requires mechanical and electrical upgrades. These costs are reflected in the Initial Five Year Action Plan.

Roadway
MassDOT is in the process of initiating a Real Time Traffic Monitoring System (RTTMS). Although the RTTMS program has been classified as Category 1 - Modernization, the expenditures associated with this implementation are included in the Initial Five Year Plan since they are programed within this initial time period.

Toll Plazas
MassDOT is currently in the process of converting the Turnpike to an All Electronic Toll System (AETS). As part of this project, the existing toll plazas will be removed. Much of the construction work associated with this project will be conducted within the initial five year period.

SECTION 7. PROJECTED FUTURE EXPENDITURES

7.1 Introduction

TranSystems has developed a projection of future expenditures necessary to maintain the Metropolitan Highway System in a State of Good Repair. While previous Triennial Reports have focused on a specific list of capital projects to determine future expenditure needs, MassDOT determined that the 2015 Triennial Report would take a different approach. The projected expenditures presented in this report attempt to capture all costs associated with maintaining and operating the Metropolitan Highway System in a State of Good Repair including maintenance needs and indirect costs. In keeping with MassDOT's intent, the projected future expenditures identified in this report reflect the recommended activities to maintain the MHS in a State of Good Repair and are not fiscally constrained.

The Projected Future Expenditures are presented for each asset class in four cost categories:

1. ***Modernization:*** This category includes projects where the primary goal is to rehabilitate or replace existing assets in poor condition that have outlived their useful lives. But that need should be leveraged to "modernize" the asset to the greatest extent practicable. These improvements can include incorporating new technology or making other enhancements to support economic development, improve mobility, reduce environmental impacts, or increase safety.

2. ***Capacity:*** This category is for projects that add new connections, or expand, the existing transportation network. While capacity projects may start with assets that are currently part of the Commonwealth's transportation system, the purpose of capacity projects is to add new assets to the system in order to meet increased new demand, such as a new lane, roadway link, bridge, transit station, service or line, or multi-use path.

3. ***State of Good Repair:*** This category includes activities required to achieve State of Good Repair goals for each asset class. As this cost category spans all asset classes, it includes a variety of activities:

   - Rehabilitation or replacement
   - Pavement management
   - Maintenance activities
   - Bridge Inspection, and other regularly scheduled asset inspection costs
   - Snow and ice removal

4. ***CRC***: This category includes projects listed under the Construction Remediation Contracts to address deficient conditions in the CA/T system.

These categories are consistent with the categories used in the upcoming Capital Improvement Plan, and are based on the report, Recommendations for MassDOT Project Selection Criteria, which was developed by the MassDOT Project Selection Advisory Council. It should be noted that, while some projects might conceivably fall under multiple categories, for clarity and consistency each project was only allocated to one specific category. Because one of the goals of this Triennial Report is to identify a

course of action that will maintain the MHS in a State of Good Repair, a majority of the expenditures fall under the State of Good Repair category. However, because ongoing and planned projects identified in MassDOT's CIP such as the ongoing AETS Conversion project and Allston Interchange Reconstruction, have been considered for inclusion in the SGR Action Plan, expenditures have been identified under the Modernization and Capacity categories.

7.2 Cost Development

TranSystems was tasked by MassDOT with the development of an independent assessment of future expenditure needs to maintain the MHS in a State of Good Repair. The projections presented in the following section have been developed based upon the SGR Action Plan laid out in Section 6 as well as additional input from MassDOT regarding ongoing and upcoming project initiatives. The projected future expenditures also include projects which are included in the FY2016 CIP, as well as other identified or planned construction projects from FY2017 and going forward It should be noted that there is a difference between 2016 CIP and actuals because spending for projects in the 2016 CIP reflects actual expenditures to date and projected construction costs.

The projected costs for each asset class were developed through an extensive data collection and analysis program. Generally, the development of costs was guided by a multi-step process:

- Compile a work task list to restore/maintain a state of good repair based upon existing conditions and industry recommended practices as discussed in Section 6;
- Identify capital projects that address identified deficiencies;
- Determine the recommended frequency for each maintenance/rehabilitation work task (i.e. annually; every 5 years, 10 years; etc.);
- Calculate the cost of each work task. The cost values were developed from a series of sources including: past MassDOT projects, MassDOT Weighted Average Bid Prices, consultation with MassDOT staff, industry trends, and industry cost data;
- Allocate actual administrative and indirect costs including annual insurance costs, energy costs and space rental, annual fleet maintenance cost, annual fuel cost, annual communications cost, administrative expenses, operational services (Transcore, etc), equipment purchase, equipment lease, and annual salaries proportionally as they relate to each asset class;

  Reconcile MassDOT's ongoing and upcoming projects with work plans identified as part of the SGR Action Plan preparation to avoid duplication of projects and to ensure all major work items have been included.

Additionally, project factors were added to work tasks to account for the following items:

Mobilization – 10%
A value of ten percent was selected as an overall average value for the wide range of work tasks included in this plan. This value was added to all projects.

Traffic Control – 10%
A value of ten percent was added for projects that will require traffic lane closures.

Engineering and CE Services – 20%
A value of twenty percent was added to all projects to account for items such as program management, survey services, design, permitting, right-of-way, construction phase engineering, material testing services and construction inspection.

Contingency – 20%
A value of twenty percent was added to all projects to account for additional scope assigned during the design phase of the project.

Location – 0% to 55%
A value ranging from zero percent to fifty-five percent was added to projects to account for anticipated cost increases based on the project location (i.e. over/under/adjacent to railroad, over water, etc.).

7.3 Expenditure Plan

The summary of Projected Future Expenditures is presented in Table 7-1 below. These costs are presented as present day (2015) dollars. Table 7-2 below presents the summary of expenditures factoring a consistent 3.5% annual escalation factor. A breakdown of year by year expenditures is included in Tables 7-5 and 7-6 at the end of this report. Additional breakdown of projected expenditures is located in Appendix A-6.

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ 56.03	$ 66.40	$ 11.46	$ 2.01	$ 7.52	**$ 143.42**	**$ 156.35**	**$ 161.45**
2. Capacity	$ 9.52	$ 4.09	$ 88.56	$ 88.56	$ 88.56	**$ 279.28**	**$ 424.40**	**$ 424.40**
3. State of Good Repair	$ 216.75	$ 227.16	$ 238.92	$ 172.71	$ 141.33	**$ 996.87**	**$ 1,782.94**	**$ 3,362.85**
4. CRC	$ 112.50	$ 67.97	$ 67.25	$ 61.09	$ 49.00	**$ 357.81**	**$ 365.81**	**$ 365.81**
MHS Total Cost	**$394.80**	**$365.63**	**$406.18**	**$324.36**	**$286.41**	**$ 1,777.38**	**$ 2,729.49**	**$ 4,314.51**

Table 7-1 Projected Expenditures (in $ millions) – Present Day (2015) by Year

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ 57.99	$ 71.13	$ 12.71	$ 2.30	$ 8.93	**$ 153.06**	**$ 169.85**	**$ 177.52**
2. Capacity	$ 9.85	$ 4.38	$ 98.19	$ 101.62	$ 105.18	**$ 319.22**	**$ 500.04**	**$ 500.04**
3. State of Good Repair	$ 224.34	$ 243.34	$ 264.89	$ 198.19	$ 167.86	**$ 1,098.62**	**$ 2,135.27**	**$ 4,837.22**
4. CRC	$ 116.44	$ 72.81	$ 74.56	$ 70.10	$ 58.20	**$ 392.10**	**$ 401.94**	**$ 401.94**
MHS Total Cost	**$408.62**	**$391.67**	**$450.34**	**$372.21**	**$340.16**	**$ 1,963.00**	**$ 3,207.10**	**$ 5,916.71**

Table 7-2 Projected Expenditures (in $ millions) – 3.5% Escalation

The following presents projected future expenditures for each of the defined asset classes. For clarity, the CRC related work tasks have not been incorporated into the defined expenditures per asset class.

Bridges

The Projected Future Expenditures includes the Routine Maintenance costs for MHS bridges annually, and Scheduled Preventative Maintenance costs on a rotating 12-year basis. Each of these costs is listed under Category 3 State of Good Repair (in $ millions).

The cost for bridge rehabilitation and replacement are listed in as Projected Future Expenditures under Category 3 State of Good Repair. Separate from the costs described above, MassDOT has a number of bridge projects currently under construction, or under design and scheduled for construction in the next several years. The anticipated budget for these scheduled projects is listed in the Capital Plan under Category 2 Capacity or Category 3 State of Good Repair, depending on the overall scope of the project.

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ 88.56	$ 88.56	$ 88.56	$ 265.68	$ 410.80	$ 410.80
3. State of Good Repair	$ 70.93	$ 73.87	$ 77.27	$ 39.21	$ 24.41	$ 285.69	$ 479.56	$ 866.77
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bridges Total Cost	**$ 70.93**	**$ 73.87**	**$ 165.83**	**$ 127.77**	**$ 112.97**	**$ 551.36**	**$ 890.35**	**$ 1,277.56**

Tunnel/Boat Sections

The Projected Future Expenditures include the Routine Maintenance costs for the MHS tunnels and boat sections annually, and Scheduled Preventative Maintenance costs on a rotating 12-year basis. Also included are the costs associated with addressing select tunnel elements that have a condition rating of four (4) or less. The cost for this work is listed in the Capital Plan under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 44.62	$ 68.92	$ 86.27	$ 58.51	$ 44.62	$ 302.95	$ 526.06	$ 972.29
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Tunnels Total Cost	**$ 44.62**	**$ 68.92**	**$ 86.27**	**$ 58.51**	**$ 44.62**	**$ 302.95**	**$ 526.06**	**$ 972.29**

Maintenance Facilities

The Projected Future Expenditures include the building maintenance and site maintenance costs for these maintenance facilities annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 6.81	$ 6.81	$ 6.81	$ 6.81	$ 6.81	$ 34.03	$ 68.07	$ 136.14
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance Facilities Total Cost	**$ 6.81**	**$ 6.81**	**$ 6.81**	**$ 6.81**	**$ 6.81**	**$ 34.03**	**$ 68.07**	**$ 136.14**

Vent Buildings

The Projected Future Expenditures include the building maintenance and site maintenance costs for these vent buildings annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 9.99	$ 15.35	$ 6.14	$ 6.14	$ 6.14	$ 43.76	$ 74.46	$ 135.85
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Vent Buildings Total Cost	**$ 9.99**	**$ 15.35**	**$ 6.14**	**$ 6.14**	**$ 6.14**	**$ 43.76**	**$ 74.46**	**$ 135.85**

Office/Retail Building

The Projected Future Expenditures include the building maintenance costs for this office/retail building annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 3.16	$ 3.16	$ 3.16	$ 3.16	$ 3.16	$ 15.79	$ 31.57	$ 63.15
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Office/Retail Building Total Cost	**$ 3.16**	**$ 3.16**	**$ 3.16**	**$ 3.16**	**$ 3.16**	**$ 15.79**	**$ 31.57**	**$ 63.15**

Communication Towers/Facilities

The Projected Future Expenditures include the ITS system expansion costs under Category 1 Modernization, and building maintenance and site maintenance costs for all communication facilities annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ 5.55	$ 5.55	$ 8.45	$ 8.45
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 4.20	$ 4.67	$ 4.97	$ 4.59	$ 1.90	$ 20.33	$ 37.39	$ 75.29
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Communication Facilities Total Cost	**$ 4.20**	**$ 4.67**	**$ 4.97**	**$ 4.59**	**$ 7.45**	**$ 25.88**	**$ 45.83**	**$ 83.73**

Toll Plazas

The Projected Future Expenditures include the cost for the toll plaza demolition/removal as well as installation and implementation of the AETS system under Category 1 Modernization. Costs to operate and maintain the AETS system annually are listed under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ 52.39	$ 64.27	$ 11.46	$ 2.01	$ 1.97	$ 132.09	$ 142.12	$ 147.23
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 0.74	$ 0.74	$ 0.74	$ 0.74	$ 0.74	$ 3.68	$ 7.35	$ 19.15
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Toll Plazas Total Cost	**$ 53.13**	**$ 65.00**	**$ 12.19**	**$ 2.74**	**$ 2.70**	**$ 135.77**	**$ 149.47**	**$ 166.37**

Walls

The Projected Future Expenditures include the costs for the activities detailed under the SGR Action Plan including routing and preventative maintenance as well as repair and replacement of select walls under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 2.36	$ 2.13	$ 2.13	$ 2.13	$ 2.13	$ 10.88	$ 21.51	$ 42.87
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Walls Total Cost	**$ 2.36**	**$ 2.13**	**$ 2.13**	**$ 2.13**	**$ 2.13**	**$ 10.88**	**$ 21.51**	**$ 42.87**

Sign Support Structures

The Project Future Expenditures include the cost to upgrade variable message signs in the Ted Williams and I-90 Connector Tunnels under Category 1 Modernization, and the cost to replace all structural sign supports under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ 1.47	$ -	$ -	$ -	$ -	$ 1.47	$ 1.47	$ 1.47
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 0.95	$ 3.17	$ 0.21	$ 0.21	$ 0.21	$ 4.76	$ 5.82	$ 7.94
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sign Support Structures	**$ 2.42**	**$ 3.17**	**$ 0.21**	**$ 0.21**	**$ 0.21**	**$ 6.23**	**$ 7.29**	**$ 9.41**

Salt Sheds

The Projected Future Expenditures include the building maintenance and site maintenance costs for these salt sheds annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 3.20	$ 3.20	$ 3.20	$ 3.20	$ 3.20	$ 15.98	$ 31.96	$ 63.92
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Salt Sheds Total Cost	**$ 3.20**	**$ 3.20**	**$ 3.20**	**$ 3.20**	**$ 3.20**	**$ 15.98**	**$ 31.96**	**$ 63.92**

Electrical/Mechanical Substations

The Projected Future Expenditures include the building maintenance and site maintenance costs for these substations annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 3.55	$ 2.99	$ 2.99	$ 2.99	$ 2.99	$ 15.50	$ 30.44	$ 60.32
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
ESS/MSS Total Cost	**$ 3.55**	**$ 2.99**	**$ 2.99**	**$ 2.99**	**$ 2.99**	**$ 15.50**	**$ 30.44**	**$ 60.32**

Pump Stations

The Projected Future Expenditures include the building maintenance costs for these pump stations annually as well as the rehabilitation costs for identified pump station under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 15.19	$ 4.57	$ 4.57	$ 4.57	$ 4.57	$ 33.49	$ 56.36	$ 102.11
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Stations Total Cost	**$ 15.19**	**$ 4.57**	**$ 4.57**	**$ 4.57**	**$ 4.57**	**$ 33.49**	**$ 56.36**	**$ 102.11**

Fan Rooms

The Projected Future Expenditures include the building maintenance costs for these fan rooms annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 4.28	$ 4.22	$ 4.09	$ 4.09	$ 4.09	$ 20.78	$ 41.25	$ 82.19
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fan Rooms Total Cost	**$ 4.28**	**$ 4.22**	**$ 4.09**	**$ 4.09**	**$ 4.09**	**$ 20.78**	**$ 41.25**	**$ 82.19**

Air Intake Building

The Projected Future Expenditures include the building and site maintenance costs for this building annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 4.27	$ 4.27	$ 4.27	$ 4.27	$ 4.27	$ 21.34	$ 42.67	$ 85.34
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Air Intake Building Total Cost	**$ 4.27**	**$ 4.27**	**$ 4.27**	**$ 4.27**	**$ 4.27**	**$ 21.34**	**$ 42.67**	**$ 85.34**

Administration/Service Buildings

The Projected Future Expenditures include the building maintenance costs for these buildings annually under Category 3 State of Good Repair. Expenditures identified in Category 2 Capacity account for the construction of a new parking facility under I-93 between Albany Street, Traveler Street, and Frontage Road (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ 9.52	$ 4.09	$ -	$ -	$ -	$ 13.61	$ 13.61	$ 13.61
3. State of Good Repair	$ 5.15	$ 3.11	$ 5.09	$ 5.09	$ 5.09	$ 23.54	$ 49.01	$ 99.96
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Administration Facilities Total Cost	**$ 14.67**	**$ 7.20**	**$ 5.09**	**$ 5.09**	**$ 5.09**	**$ 37.15**	**$ 62.62**	**$ 113.57**

Garage

The Projected Future Expenditures include the building maintenance costs for this garage annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 6.09	$ 6.09	$ 6.09	$ 6.09	$ 6.09	$ 30.46	$ 60.92	$ 121.84
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Garage Total Cost	**$ 6.09**	**$ 6.09**	**$ 6.09**	**$ 6.09**	**$ 6.09**	**$ 30.46**	**$ 60.92**	**$ 121.84**

Emergency Response Stations

The Projected Future Expenditures include the building and site maintenance costs for these stations annually under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 6.57	$ 6.02	$ 6.02	$ 6.02	$ 6.02	$ 30.64	$ 60.72	$ 120.89
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
ERS Total Cost	**$ 6.57**	**$ 6.02**	**$ 6.02**	**$ 6.02**	**$ 6.02**	**$ 30.64**	**$ 60.72**	**$ 120.89**

Roadway Pavement

The Projected Future Expenditures include the pavement maintenance and pavement replacement costs under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 4.89	$ 4.89	$ 4.89	$ 4.89	$ 4.89	$ 24.43	$ 48.87	$ 97.74
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Roadway Pavement Total Cost	**$ 4.89**	**$ 4.89**	**$ 4.89**	**$ 4.89**	**$ 4.89**	**$ 24.43**	**$ 48.87**	**$ 97.74**

Roadway Assets

The Projected Future Expenditures include the installation of real time traffic monitoring and stormwater retrofits under Category1 Modernization, and roadway asset maintenance and roadway asset replacement costs under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ 2.17	$ 2.14	$ -	$ -	$ -	$ 4.31	$ 4.31	$ 4.31
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 17.89	$ 7.08	$ 8.09	$ 8.09	$ 8.09	$ 49.24	$ 89.70	$ 170.62
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Roadway Assets Total Cost	**$ 20.06**	**$ 9.22**	**$ 8.09**	**$ 8.09**	**$ 8.09**	**$ 53.55**	**$ 94.01**	**$ 174.93**

Interchange Pavement
The Projected Future Expenditures include the pavement maintenance and replacement costs under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 0.53	$ 0.53	$ 0.53	$ 0.53	$ 0.53	$ 2.63	$ 5.27	$ 10.54
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Interchange Pavement Total Cost	**$ 0.53**	**$ 0.53**	**$ 0.53**	**$ 0.53**	**$ 0.53**	**$ 2.63**	**$ 5.27**	**$ 10.54**

Interchange Assets
The Projected Future Expenditures include the pavement maintenance and replacement costs under Category 3 State of Good Repair (in $ millions).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	10 Year Total	20 Year Total
1. Modernization	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. State of Good Repair	$ 1.40	$ 1.40	$ 1.40	$ 1.40	$ 1.40	$ 6.99	$ 13.97	$ 27.95
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Interchange Assets Total Cost	**$ 1.40**	**$ 1.40**	**$ 1.40**	**$ 1.40**	**$ 1.40**	**$ 6.99**	**$ 13.97**	**$ 27.95**

Prudential Passageway
The Projected Future Expenditures include the routine maintenance and scheduled preventative maintenance costs for the prudential passageway annually under Category 3 State of Good Repair as part of the Tunnel/Boat Section asset class.

Parks
The Projected Future Expenditures include the structure and site maintenance costs for this park annually under Category 3 State of Good Repair.

7.4 Initial Five Year Action Plan

The initial five year time period of the Capital Plan prepared as part of this Triennial Inspection is focused on two main goals: 1. Improve the Turnpike condition to be considered in a State of Good Repair as defined previously in this report and 2. Implement a defined maintenance plan that is sufficient to keep assets in a State of Good Repair. To accomplish these goals, it is estimated that $1.9 Billion (2015 dollars) will be needed over the next five years (2016-2020) as showed in Table 7-3 below.

Cost Category	2016	2017	2018	2019	2020	5 Year Total
1. Modernization	$ 56.03	$ 66.40	$ 11.46	$ 2.01	$ 7.52	**$ 143.42**
2. Capacity	$ 9.52	$ 4.09	$ 88.56	$ 88.56	$ 88.56	**$ 279.28**
3. State of Good Repair	$ 216.75	$ 227.16	$ 238.92	$ 172.71	$ 141.33	**$ 996.87**
4. CRC	$ 112.50	$ 67.97	$ 67.25	$ 61.09	$ 49.00	**$ 357.81**
MHS Total Cost	**$394.80**	**$365.63**	**$406.18**	**$324.36**	**$286.41**	**$ 1,777.38**

Table 7-3 - Projected expenditures over initial five years (in $ millions) in 2015 dollars

Cost Category	2016	2017	2018	2019	2020	5 Year Total
1. Modernization	$ 57.99	$ 71.13	$ 12.71	$ 2.30	$ 8.93	**$ 153.06**
2. Capacity	$ 9.85	$ 4.38	$ 98.19	$ 101.62	$ 105.18	**$ 319.22**
3. State of Good Repair	$ 224.34	$ 243.34	$ 264.89	$ 198.19	$ 167.86	**$ 1,098.62**
4. CRC	$ 116.44	$ 72.81	$ 74.56	$ 70.10	$ 58.20	**$ 392.10**
MHS Total Cost	**$408.62**	**$391.67**	**$450.34**	**$372.21**	**$340.16**	**$ 1,963.00**

Table 7-4 - Projected expenditures over initial five years (in $ millions) escalated at 3.5%/yr

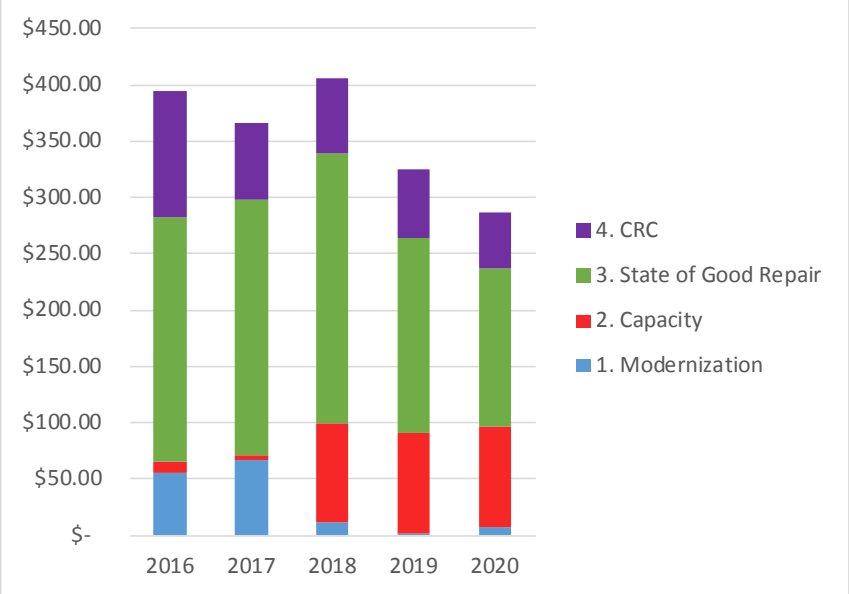

Figure 7-1 - Breakdown of projected expenditures (in $ millions) in 2015 dollars

Initial Five Year Expenditure by Asset Class

As depicted in Figure 7-2, 31% of overall expenditures are allocated to the MHS bridges. Additionally, 17% of overall expenditures are allocated to various costs associated with the tunnel structures while 20% of costs are associated with CRC actions.

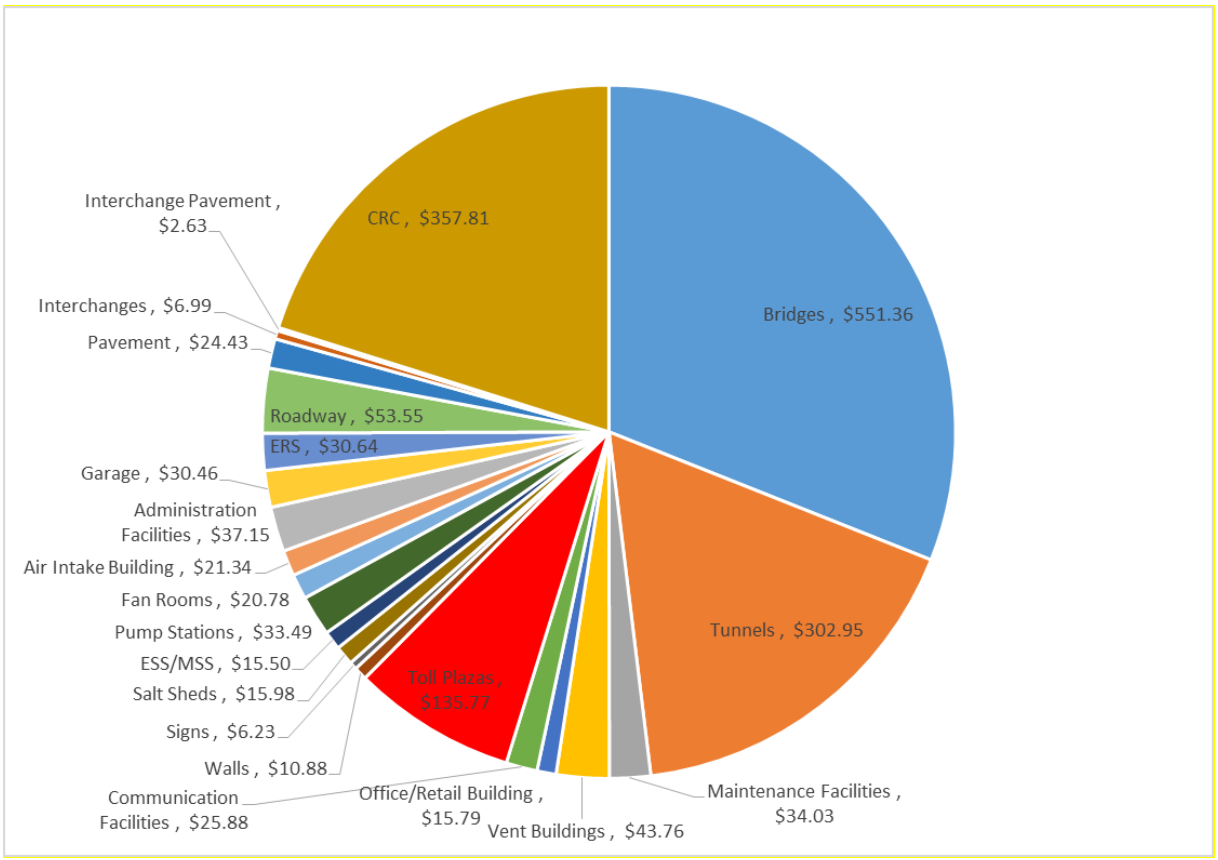

Figure 7-2 – Expenditure Breakdown (in $ millions) by Asset Class

7.5 Expenditure Summary

The following tables present a summary of projected expenditures for a 20 year planning period in present day (2015) costs (Table 7-5) and future costs escalated at 3.5%/year (Table 7-6).

Cost Category	2016	2017	2018	2019	2020	5 Year Total	2021	2022	2023	2024	2025	10 Year Total
1. Modernization	$ 56.03	$ 66.40	$ 11.46	$ 2.01	$ 7.52	**$ 143.42**	$ 4.91	$ 2.01	$ 2.01	$ 2.01	$ 2.01	**$ 156.35**
2. Capacity	$ 9.52	$ 4.09	$ 88.56	$ 88.56	$ 88.56	**$ 279.28**	$ 88.56	$ 56.56	$ -	$ -	$ -	**$ 424.40**
3. State of Good Repair	$ 216.75	$ 227.16	$ 238.92	$ 172.71	$ 141.33	**$ 996.87**	$ 148.03	$ 160.20	$ 166.29	$ 158.67	$ 152.88	**$1,782.94**
4. CRC	$ 112.50	$ 67.97	$ 67.25	$ 61.09	$ 49.00	**$ 357.81**	$ 8.00	$ -	$ -	$ -	$ -	**$ 365.81**
MHS Total Cost	**$394.80**	**$365.63**	**$406.18**	**$324.36**	**$286.41**	**$ 1,777.38**	**$ 249.49**	**$ 218.77**	**$168.29**	**$160.67**	**$ 154.89**	**$2,729.49**

Cost Category	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	20 Year Total
1. Modernization	$ 2.01	$ 2.01	$ 1.09	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 161.45**
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 424.40**
3. State of Good Repair	$ 169.60	$ 160.69	$ 170.21	$ 173.23	$ 141.28	$ 132.40	$ 144.22	$ 155.95	$ 165.40	$ 166.92	**$ 3,362.85**
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 365.81**
MHS Total Cost	**$171.61**	**$162.70**	**$171.30**	**$173.23**	**$141.28**	**$ 132.40**	**$ 144.22**	**$ 155.95**	**$165.40**	**$166.92**	**$ 4,314.51**

Table 7-5 Projected 20 Year Expenditures (in $ millions) – Present Day (2015) Costs

Cost Category	2016	2017	2018	2019	2020	5 Year Total	2021	2022	2023	2024	2025	10 Year Total
1. Modernization	$ 57.99	$ 71.13	$ 12.71	$ 2.30	$ 8.93	**$ 153.06**	$ 6.03	$ 2.55	$ 2.64	$ 2.73	$ 2.83	**$ 169.85**
2. Capacity	$ 9.85	$ 4.38	$ 98.19	$ 101.62	$ 105.18	**$ 319.22**	$ 108.86	$ 71.96	$ -	$ -	$ -	**$ 500.04**
3. State of Good Repair	$ 224.34	$ 243.34	$ 264.89	$ 198.19	$ 167.86	**$ 1,098.62**	$ 181.96	$ 203.82	$ 218.97	$ 216.25	$ 215.66	**$2,135.27**
4. CRC	$ 116.44	$ 72.81	$ 74.56	$ 70.10	$ 58.20	**$ 392.10**	$ 9.83	$ -	$ -	$ -	$ -	**$ 401.94**
MHS Total Cost	**$408.62**	**$391.67**	**$450.34**	**$372.21**	**$340.16**	**$ 1,963.00**	**$ 306.69**	**$ 278.33**	**$221.61**	**$218.98**	**$ 218.49**	**$3,207.10**

Cost Category	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	20 Year Total
1. Modernization	$ 2.93	$ 3.03	$ 1.71	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 177.52**
2. Capacity	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 500.04**
3. State of Good Repair	$ 247.61	$ 242.82	$ 266.20	$ 280.41	$ 236.70	$ 229.58	$ 258.82	$ 289.67	$ 317.98	$ 332.14	**$ 4,837.22**
4. CRC	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 401.94**
MHS Total Cost	**$250.54**	**$245.85**	**$267.91**	**$280.41**	**$236.70**	**$ 229.58**	**$ 258.82**	**$ 289.67**	**$317.98**	**$332.14**	**$ 5,916.71**

Table 7-6 Projected 20 Year Expenditures (in $ millions) – Escalated Costs